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THE DYEING INDUSTRY

BEING A THIRD EDITION OF "DYEING IN GERMANY AND AMERICA"

BY

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PREFACE

I HAVE seized the opportunity presented by the need for a new edition of this book to add a new chapter on recent progress in the Industry, founded on my articles in *Annual Reports on Applied Chemistry* issued by the Society of Chemical Industry, 1917–1918. These reports have also been utilised to provide some of the information given in the new chapter on Colour Production. Since the book now deals as substantially with the Industry in Great Britain as it does with the Industry in other countries, it seems logical to change the title which it bore in previous editions, "Dyeing in Germany and America," into the one which is now used. It is gratifying to find that the book has been deemed worthy of translation and that an edition in French will soon make its appearance.

S. H. H.

MANCHESTER,
September 1919.

PREFACE TO THE SECOND EDITION OF "DYEING IN GERMANY AND AMERICA"

THE first edition of this book was issued in 1907 as "a Report to the Electors of the Gartside Scholarship of the University of Manchester on the Results of a Tour in the United States of America and Germany in 1905–1906," and was intended to give a general survey of the dyeing and allied industries of these countries.

The very favourable reception awarded to the book has exhausted the supply of copies and necessitated the issue of this new edition. Although no further visit has been paid to either of the countries, I have been able to add considerably to what appeared in the first edition, chiefly as the result of experience gained during the past nine years, firstly as a demonstrator in the Dyehouse of the Manchester College of Technology, and secondly, as a works chemist and manager. Naturally, this experience is most in evidence in those parts of the book dealing with the branches of the industry with which I am the most familiar. I have also taken the liberty of including certain material which I have published in various journals since the issue of the first edition.

It is hoped that this edition will be useful to the student requiring a general knowledge of the industry, to the publicist seeking a comparison between the industrial conditions in this and other countries, to the general reader, and also to the practical dyer, who may find in these pages some things of value and interest to him.

In the preparation of this edition I have received much assistance from the many helpful suggestions made by reviewers when the book was first published. I am also indebted to these gentlemen for the rectification of several errors which appeared therein. I wish to place on record my appreciation of the care taken in the publication of the present edition by H. M. McKechnie, Esq., Secretary of the Manchester University Press; also to repeat my thanks to Arthur Jones, Esq., M.A., for the help he gave me with the first edition.

S. H. HIGGINS.

LUNCARTY, PERTH, N.B.,
July 1916.

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CHAPTER I

GENERAL

The art of dyeing—Influence of chemistry—Opposition to progress—Hank-dyeing and washing—Cloth-dyeing.

THE art of dyeing is very old, as the following quotation from Pliny shows: "Garments are painted in Egypt in a wonderful manner, the white cloths being first smeared, not with colours, but with drugs which absorb colours. These applications do not appear on the cloths, but when the cloths are immersed in a cauldron of hot dyeing liquor they are taken out painted the moment afterwards. It is wonderful that, although the dyeing liquor is only of one colour, the garment is dyed by it of several colours, according to the different properties of the drugs which have been applied to the different parts: nor can this dye be washed out. Thus the vat, which would doubtless have confused all the colours if the cloth had been immersed in a painted state, produces a diversity of colours out of one, and at the same time fixes them immovably." Thus we have evidence that at an early period the practice of what is now known as polygenetic colour-dyeing was carried out. Since such knowledge of dyeing existed in these early times it is surprising that it is only during the last few centuries that marked progress has been made. The discovery of America influenced the art of dyeing so materially that its real development dates from that event. Mexico furnished cochineal, and, later, the beautiful tropical indigo displaced to a large extent the ancient woad of England. We find that the law restricted the dyeing industry in all countries: sometimes the methods of dyeing were strictly defined and no others were permitted; at other times the districts in which dyeing was

allowed were stated; and in some periods a duty was placed on all dyed cloth. For instance, at one time logwood was not allowed to be used for dyeing blues, as the colours thus produced were said to be fugitive. An Act of Parliament of 1552 limited the number of colours which might be used; William III. added to the list; and later legislation allowed the free use of dye-stuffs. These obstacles hindered, to some extent, the progress of the dyeing industry, but it is only in quite recent times that great advances have been made.

The introduction of chemistry into the industry has indefinitely enlarged its resources by showing how to produce varieties of colours extending through the whole range of the prismatic spectrum, and has enabled the dyer to fix and render durable many of those beautiful vegetable dyes the ephemeral nature of whose brightness formerly detracted from their utility. Along with these improvements the nature of the substance to be dyed has received careful scientific consideration; the processes have been adapted to suit the fibres being dyed, and mordants have been introduced by means of which peculiar shades have been produced, the most diverse fabrics dyed together and perfect fixity given to the colours.

Yet, during its rapid development, the dyeing industry had to combat many prejudices, the greatest of which was the reluctance of the dyers themselves to adopt the new methods when introduced. The utility of colours dyed without mordants was not at first recognised, and it was a long time before the substantive cotton colours could get a footing. The general adoption of metallic mordants was opposed; but the discovery of alizarine red and, later, of alizarine blue brought in this method, and it has gradually grown in use until now it is one of the most important methods of dyeing. It must be remembered, however, that every improvement in every trade is received with opposition of some kind, and the history of dyeing shows the industry to have been no exception to the rule. The preliminary difficulties may be great, and unwillingness to discard the old methods may exist, but the fact that the new methods gain acceptance in other quarters show their utility, and ought to urge all beyond initial obstacles.

As to the location of the dyeing industry, we have in Germany:

1. *North-West Germany*, including Rhineland and Westphalia. In this district the principal centres are Crefeld for silk, München-Gladbach for cotton, and Elberfeld-Barmen for general manufacture, especially dyeing.

2. *Middle Germany*, containing what is usually called "the Saxony Industry" and spread over a large area. The industry in this district is very old. Chemnitz and Zwickau are important centres.

3. *South-West Germany*, where the industry is connected with the French and Swiss industries. Mülhausen is the principal town. Mülhausen is an important fine cotton centre, and much fine printing is done in this district for English and French firms. The work is totally different from that of other parts of Germany. The München-Gladbach industry is largely devoted to the production of cotton blankets. In Chemnitz the dyeing is of a varied nature. The machines used in the textile districts mentioned are in many cases of British manufacture, or copies of the same, and even in the trade schools British machinery is used. Yet the Germans are now producing a large number of textile and dyeing machines, and even exporting them to Britain.

In America the dyeing industry is scattered. In the Philadelphia district the dyeing of carpets and coarse goods is the principal business. In the Southern States, where bleaching and dyeing are comparatively new industries, there are some fine works; but the works of the New England States are the most important for the present review. Nearly everything that is manufactured anywhere in the United States is made in New York State. It has a population of over 7,000,000, a foreign commerce only exceeded by four countries, and is the leading State of the United States in many important industries. Yet, turning farther north, we find New England contains two-thirds of all the cotton spindles and three-quarters of all the looms of the United States, while Fall River makes three-quarters of the print cloth produced in that country.

Dyeing in Europe was first effected in the yarn form, and this method is still largely used. *Hank-dyeing* has

not changed much of recent times, and in dye-houses in all countries men can be seen standing over wooden vats changing periodically the wooden sticks, from which the hanks hang into the dye liquor. The hanks are lifted, turned, and dropped back again, while to improve the evenness of the dyeing the positions of the sticks are changed regularly so that all experience the same concentration of dye-stuff.

Machines have been devised to imitate this movement, but few of these have been adopted to any large extent. Such machines are really only suitable for dyeing large quantities of yarn the same colour. The author did not see any such machines at work in Germany, but in America the Klauder-Weldon machine for this purpose was often seen (see p. 63). In the United States, however, hank-dyeing is not so important as it used to be. They make so many cloths where the warp is the same count as the weft, that both warp and weft are receiving the same treatment before weaving. Both are dyed together in the warp-dyeing machine, and then taken, part to be quilled and part to be beamed. This is said to be a cheaper process than separately treating the warp and weft yarns in the more usual way. As regards hank-dyeing machines, it is evident that they can never wholly replace hank-dyeing by hand, for certain colours require special care, and it is useless to attempt to design machines to meet each special operation.

After dyeing, the hanks must be washed, this operation being of importance. Machines have been devised for this purpose. The simplest method is to pass the hank alternately through water and between a pair of squeezing rollers. The washing-machines are again designed to imitate washing by hand. Thus, in one machine the hank is lifted out of the water, plunged rapidly in again, and at the same time turned.

Haubold's—a large machine firm in Chemnitz, Saxony—build a machine which is very economical and has a large production. It consists of a circular vat with a partition fixed radially at one part of the rim of the vat. Fresh water is conducted in at one side of this partition and the dirty water flows away at the other side, that is, after

having traversed round the vat and washed the hanks which are suspended from copper rods placed radially on the vat. Each of these rods is covered with a square porcelain part on which the hanks hang. The porcelain parts revolve, thus moving the hanks in the water, while the whole wheel carrying the hanks moves round with a jerky motion. During the revolution of the wheel, the hanks first meet dirty water then cleaner water as they revolve, until finally they meet clean water and are taken out. The hanks are well and rapidly washed, and as the washing is on the counter-current system, the water is economically used. The machine is supplied in three sizes, with 12, 18, and 27 copper radii, and is suitable for all classes of yarn.

Hank-dyeing and washing are still principally done by hand, and at Chemnitz workmen are seen standing on low bridges crossing the river and washing hanks in the running water. This peculiar sight may be witnessed all along the winding river. In the Barmen district such a practice is prevented by the bad state of the river, for only on a very wet Sunday, and when the factories have been closed some hours, can the Wupper be considered worthy of such usage.

Cloth-dyeing is done on the jigger or on the rope form, and big works abroad were seen using both methods. The dyeing of mordanted cloth was done in the rope-dyeing machines, as the mordanting assured even dyeing and made the use of the jigger unnecessary. It was a frequent occurrence to see a line of rope-dyeing machines at work in German works. These machines require little attention, but because of the difficulty of washing it is almost necessary to have different machines for different colours before good results can be obtained. This remark also applies to the use of jiggers for dyeing. In Germany some of the jiggers had extra rollers so as to increase the time of immersion of the cloth in the dye liquor; but since dyeing is really done more in the batch than while in the liquor, the advantage of these rollers is questionable.

At Mülhausen, as at Chemnitz, the river is used directly for washing, and washing-machines are directly built over branches of it. Most of the works congregate about the rivers and streams.

CHAPTER II

COP-DYEING

Its object—Selection of colours—The difficulties involved—Machines of two classes—Comparison of these machines—Three important machines—Perfection not attained.

UNTIL comparatively recently, cotton yarn had to be dyed in the hank form: the cop produced by the spinning-machine was unwound, the yarn made into the hank form, dyed, then rewound to the cop form and placed in the shuttle. During this operation of unwinding and rewinding, cotton was lost owing to the entangling of the threads, and cop-dyeing arose to save the trouble mentioned and thus to economise both labour and material. Cop-dyeing originated in the Manchester district about thirty years ago, and has now assumed considerable dimensions in Germany. Many machines are in use for cop-dyeing, but the success of the operation seems to depend not so much on the machinery used as on the proper selection of the dye-stuffs and on the careful handling of the machines.

During the dyeing operation the dye liquor has to be forced through the cop, and in this way the material of the cop acts as a kind of filter for the dye-stuff. It is therefore evident that success in cop-dyeing can best be attained by using perfectly soluble colours, which leave no residue in the dye-bath; otherwise there is a tendency towards uneven dyeing, and to concentration of the dye-stuff on the outside of the cop. This is partly counteracted in some machines by periodically reversing the direction of flow of the dye liquor through the cop.

Consideration shows us that many colours, as aniline black, turkey red, etc., cannot be dyed with success on

cops; others, such as indigo, are difficult to manage. The dyeing with sulphur colours is also difficult because of their tendency to oxidise on the outside of the cops, thus producing unevenness. In using these colours, the cops must be kept immersed in the dye liquor during the dyeing operation. Those colours which are slowly taken up by the fibres are the best to use in cop-dyeing, as even penetration is obtained; dyeing with basic colours, which act quickly, is difficult. To overcome the difficulties mentioned, various precautions are taken, and the colour firms give every assistance in that direction by their carefully prepared recipes. Moreover, in cop-dyeing the difficulties are accentuated by the fact that any mistakes are not revealed to the dyer, who cannot tell if he is sending black cops with white cores to the weaver. If the latter is not an observant person, pieces of cloth may thus be spoiled.

The machines for cop-dyeing are of two classes: (1) those in which the cops have solid spindles, and (2) those in which the spindles of the cops are perforated.

In the first class the cops containing the solid spindles, which serve to keep the cops from becoming damaged, are packed together into as uniform a mass as possible by means of cotton waste and other such material. Steam is first sent through the mass and then the dye liquor. The success of the operation depends on good packing, for, if the dye liquor passes along certain channels only, the dyeing of the cops is not uniform. One of the oldest of these machines and the simplest is the Mommer machine, in which the cops are tightly packed in a square box which has two of its opposite sides perforated. The dye liquor is pumped between these perforations and through the mass in the box. By reversing the direction of the dye liquor more even penetration is obtained, for, if certain channels are produced during the passage of the dye liquor in one direction, it is not likely that channels will be formed in the same places when the pump is reversed and the dye liquor travels in the other direction. In Cohnen's machine the cops can be hydro-extracted immediately after dyeing, by merely revolving the box in which the cops are packed. The machine acts in the same way as the one previously described, but the arrangement

for hydro-extracting is very convenient. The cops ca thus be dyed, washed, and hydro-extracted without takin out of the machine. The machine is specially suitable fc dyeing basic colours on cops, for in this case it is necessar to hydro-extract after each operation if uneven dyeing i to be avoided. The Obermaier machine, such as is use for dyeing loose fibres, can also be used for dyeing cop with solid spindles.

Interest in the solid spindle machines, however, i rapidly decreasing, and attention is being given to machine of the second class. Some machines can, however, b adapted to dye by both systems. For instance, th author saw a machine made by Schirp of Barmen bein used for dyeing cops with solid spindles, whereas thi machine is usually employed for dyeing according to th other system.

The penetration of the dye liquor in the machine using perforated spindles is more uniform, and this facto has decided in their favour. Further, the power to driv the dye liquor through the cops is much less than in th first system. In the second system, the dye liquor i forced into the perforated spindle on which each cop i placed, through the perforations of the spindle, througl the cop surrounding the spindle, and back into the dye bath. In this way each cop receives individual treatment instead of being penetrated by the dye liquor in a mas as in the first system. Formerly there was a difficulty ir transferring the cops to and from the metallic spindle used in these machines, but, later, perforated paper spindle were introduced, which remain inside the cops during th operations and keep the threads in position. The metalli spindles of the dyeing machines fit inside the paper spindles After dyeing, the cop along with the paper spindle is taker to the hydro-extractor.

One case of uneven cop-dyeing, which had been causec by the paper spindle, came to the author's notice whil in Germany. The inside of the cop, immediately next to where the paper spindle had been, was more deeply dyec than the remainder of the cop. Investigation showed tha the alum used in the manufacture of the paper had actec as acid to the dye liquor, drawn the dye-stuff from solution

and concentrated it on the part of the cop immediately next to the paper.

In the case of the perforated spindle machines the direction of motion of the dye liquor is altered from time to time by reversing the pump, in order again to ensure uniformity of dyeing. Any impurities or solid particles of any kind in the dye-bath, which rise to the top of the dye-bath, tend to fill up the top holes of the perforated spindles and to thus produce uneven dyeing.

Modern perforated spindle machines: (1) Grämiger's, (2) Haubold's, (3) Schirp's, and (4) Pornitz's. Grämiger's, one of the first of this type, has been improved in England, and is used for dyeing indigo on cops. Haubold's machine was seen at work by the author in the dye-works of Herr Haase, its inventor. This works is situated at Neukirchen, a few miles over the hills from Chemnitz, and is principally concerned with the dyeing of cops and stockings. Chemnitz has a large business in the dyeing of stockings. The cop-dyeing machine consists of two parts, a dye-bath of tun-dish shape and a receptacle for the dye liquor. The bottom of the dye-bath is perforated, and in these perforations the spindles carrying the cops are screwed. The dye-bath is connected through a pump with the dye-vessel. The pump draws the liquor from the dye-vessel, forces it through the cops into the dye-bath until the liquor fills the dye-bath, and then draws some of the liquor back again through the cops into the dye-vessel. The cops are kept wholly immersed in the dye liquor during the process, and many alternations of the pump ensure even dyeing. The passages of the dye liquor, first in one direction and then in the other, take place about twenty times during an hour, according to the nature of the dyeing. If four machines are run together, as was the case at this works, one engine suffices for all, but with single machines the cost of driving becomes relatively higher. The machine, which was first built in 1892, costs about £600. It is suitable for cotton and wool cops, and the products, the author found, stood minute examination. After dyeing, the cops were put in small baskets and arranged in a circle inside a hydro-extractor. After hydro-extracting they were dried in a chamber through which a strong

current of hot air was passed. If the cops dry too slowly, there is a tendency for the upper side of the cop to dry first, to extract the dye liquor from the lower part, and thus produce uneven dyeing.

The Schirp machine consists of a stout square box with removable sides. In the middle of this box is another box, which might be considered a longitudinal section of the larger one. On both faces of the smaller box the perforated spindles carrying the cops are placed, so that the spindles project into the space of the larger box. The smaller box is fitted with the cops, wheeled into position, and then the dye liquor is forced into the small box, through the cops into the larger box, and round again in circulation. As in the other cases, the direction of the dye liquor is reversed from time to time.

In the Pornitz machine the cop carrier is a perforated cylinder, the cops taking up the whole of the round surface. When the cops have been fitted into position, this cylinder is lowered by means of a chain into the dye-bath, which is a cylindrical vessel big enough to admit the cops. By means of compression and suction the dye liquor is made to pass from the dye-bath through the cops into the dye reservoir. Fresh dye-stuff can be added to the liquor while in the reservoir, and in this way slow and even dyeing assured. The suction and compression are performed by means of a double-acting air-pump. The machine can also be used for dyeing warps; for this purpose the warps are wrapped round the cylinder of the machine over the perforations, which usually carry the cop spindles. The dye reservoir is usually placed underneath the dye-bath so as to save space.

In all these machines the cops have first to be steamed and hot water sent through them before dyeing, in order to ensure even penetration. Penetration is of course assisted by "boiling out" the cops on a kier before dyeing, or by adding turkey red oil to the water used for "wetting out" the cops.

At one works cops were seen being dyed in a foam dyeing-machine. The cops were tightly packed in the top of an upright cylinder, while at the bottom of the cylinder the dye liquor, containing soap, was made to

froth up by means of steam. When the bubbles burst, the air round the fibres is driven away and the dye-stuff attracted. This method is said to be successful in dyeing certain shades on cheeses.

The author saw no cop-dyeing machines in the United States; cop-dyeing is too delicate a process for the American class of trade.

Nearly all the cop-dyeing machines in use in Germany are very similar to each other, different forms being merely modifications of the same principal idea. The production of machines for sale is as yet little developed. Mommer of Barmen informed the author that they no longer build their machine, because there is no demand for it.

Of recent years the dyeing of cops has not been much developed, and in spite of careful attention to the difficulties attendant upon the operation, perfect penetration has not been attained. The Obermaier machine is successful for the dyeing of loose wool, but it has not been so successful in the dyeing of cops. The Theis apparatus is much used in Westphalia and Holland for the bleaching of cops; it is also said to be satisfactory for dyeing. The machines used for cop-dyeing do not vary much, and from time to time old types are improved.

CHAPTER III

SULPHUR COLOURS AND INDIGO

Fastness of sulphur colours—Importance as cotton dyes—Their tendering action on cotton—Use for wool dyeing—Machines used for dyeing sulphur colours—Natural and synthetic indigo—Substitutes for indigo—Sulphur blues and indigo.

THE first sulphur dye-stuff was Cachou de Laval. Vidal black was afterwards produced by Vidal, and was the first real member of this important class of dye-stuffs, for it was by imitating Vidal's method of production that other sulphur colours were produced. These dye-stuffs were at one time known as " the colours of the future," and nowadays they are recognised as very important cotton dyes. Their brilliancy, deepness of shade, fastness, and cheapness have created quite a revolution in the dyeing industry. Cassella's sulphur blues are well-known colours, and the Hoechst thiogen violets are bright, clear shades. The latter firm claim that their thiogenpurpur was the first red sulphur dye-stuff to be put on the market. It has been stated, however, that other firms had previously had products of a similar nature which they did not deem worthy of being placed on their lists. Of recent years a large number of sulphur colours have been placed on the market, and among these the brands of sulphur blacks have been of special importance. All the colour firms have brought out sulphur blacks of great purity and concentration. Their beauty of shade is beyond dispute, and only in fastness to bleaching powder solution do they fail to compare with aniline black.

The fact that sulphur colours are apt to cause the tendering of the cotton fibre on which they are dyed, has

prevented them from becoming of still greater importance in the dyeing industry. The tendering does not take place for some time after the dyeing, but in some cases cotton goods, which had been dyed a year previously, had become quite rotten. The cause of the tendering seems to be due to the development of sulphuric acid by the oxidation of the sulphur contained in the dye-stuffs. After-treatment with copper salts accelerates this action and should not be performed. Chroming is recommended, but many dyers object to this extra treatment, saying it is costly and the shade is altered thereby. There is no doubt, however, that chroming, or treatment with some other oxidising agent, as hydrogen peroxide, brings about the full oxidation of the reduced sulphur dye-stuff, and thus produces the fullest shade immediately. To overcome the tendering caused by these dye-stuffs small amounts of certain chemicals, which neutralise the sulphuric acid as it is produced, are sometimes left in the cloth. For instance, sodium acetate is employed for this purpose, and also several patent substances.

Sulphur colours are reduced by sodium sulphide solution, and the solution thus produced used for impregnating the material to be dyed. The colour is developed by the gradual oxidation of the reduced solution in the air, and in most cases a change of colour of the material during the oxidation is noticeable. As regards the temperature at which dyeing takes place, this varies for different brands. Many sulphur blacks dye best just below boiling point, but 60° C. is sometimes high enough. A low temperature is preferable in many cases, since slow oxidation results and the dyeings are more uniform. A slightly faster result is obtained at high temperatures, but at low temperature the cotton is better preserved. For light shades 30° C. is often high enough, while some of the indigo brands may be dyed cold with advantage. The amount of sodium sulphide to be added to the bath is also of importance, as a quantity which is sufficient to reduce the dye-stuff is not always enough to fix the dye-stuff on the fibre. Since sodium sulphide solution attacks the wool fibre, sulphur dye-stuffs do not find extensive favour in the dyeing of fabrics containing wool. By using other

reducing agents however, such as hydrosulphites, sulphites, etc., in place of the sodium sulphide, this objection has been somewhat overcome. But it has been found that on using these reducing agents the results are not exactly the same as those produced by sodium sulphide.

For dyeing cloth with sulphur colours the ordinary jigger is much used, but the author also saw jiggers at work in which the cloth was kept wholly immersed in the dye liquor during the dyeing operation. Exposure to the air during dyeing is said to cause bronzy precipitates on the cloth. The addition of a little glue to the dye-bath is said to prevent these bronzy patches, and thus to assist the dyeing on the jigger. In dyeing hanks with these colours, exposure to air during the dyeing operation is also avoided. The Klauder-Weldon machine is used for this operation (see p. 63) in the United States.

The author found that slop padding was taking the place of dyeing for some classes of colours. Every dyer knows the difficulty of dyeing evenly, and in cases of mordanting and developing dye-stuffs on the fibre the difficulties are increased. Tannic acid divides itself fairly evenly over the fibres, so that impregnation in this case is easily accomplished; but in dealing with some of the chromium mordants and other compounds, difficulties arise. Moreover, tannic acid can be fixed in the wet state, whereas some agents must be dried evenly on the cloth before proceeding to the other operations. Difficulties of this kind have led to the introduction of padding. Thus, in Germany and America, mordants were often padded, and then the dyeing done in the strand dyeing machines. In padding, the cloth passes through the liquor to be padded, and is then squeezed evenly by a pair of rollers. One of these rollers is usually of brass and the other rubber covered. Padding with sulphur colours is difficult, because to ensure a uniform result the dye-stuff should be completely dissolved in the padding liquor. In Germany the author found glucose was used as a reducing agent in preparing sulphur colours for padding. The brass roller of the padding mangle was replaced by an iron one, since brass and copper parts are attacked by sulphur colour solutions.

Printing with sulphur colours is now performed by using special reducing agents for preparing the printing pastes. Cassella's first used caustic soda and glycerine.

Sulphur colours are much used in the United States. For instance, one representative of a German colour works told the author that he had sold a million pounds of colour in a very short time. Sulphur blacks were in great demand. The introduction of these colours has led to changes in the machinery in use; copper parts have been replaced. Some firms in the United States claim to have the best machinery for dyeing sulphur colours, but whether this is the case or not cannot be determined because these firms resolutely refuse to place their machines on view. Representatives of the colour makers were not allowed to see the machines, and these gentlemen found themselves in the peculiar position of giving instructions and seeing the firm's servants oscillating between themselves and the dye-house.

Sulphur dye-stuffs have nowadays become so important that they have challenged the position of some of the older fast colours. As previously mentioned, sulphur blacks are used in place of aniline black, and we also find that some sulphur blues have replaced the use of indigo to some extent.

Indigo, one of the oldest and still the most important dye-stuff, has a history full of interest. Not only has the natural article had to overcome the opposition of substitutes; this opposition it counteracted very well, until the production of synthetic indigo caused the natural article to become of less and less importance. Indeed, it is only the present war which has caused a renewed interest in this colour. In 1880 the chemical constitution of indigo was declared, an event which led later to the production of synthetic indigo on a commercial scale. A large industry has arisen therefrom, as the following figures show: from 1896 to 1904 Germany's export of synthetic indigo increased in value from 6·4 to 25 million marks, and the latest returns published (for the year 1913) show these to have increased to 40 million marks. As a result, during the years 1899 to 1903 the price of indigo fell 50 per cent. In 1900, Dr. Brunck of the Badische Anilin und Soda

Fabrik stated that the quantity of indigo produced annually in their factory would require the cultivation of more than a quarter of a million acres of land in the home of the indigo plant. It has been prophesied that natural indigo will be as dead as madder in a few years' time, yet we find it has to some extent held its position in the East, and various Commissions have tried to improve the cultivation in order to increase the production. But there is obviously a limit to which the production can be improved, for plant life does not admit of the thorough comprehension that operations in a colour works do, and the producers of synthetic indigo have the price of indigo and production very much in their own hands.

The crippling of the synthetic indigo industry by the war has been turned to account by the British and Indian press as an occasion to revive interest in the restoration of the natural production. The movement to break the German synthetic indigo monopoly was started in London three years ago, but despite all efforts the vegetable dye failed to make headway. Many dyers and consumers would have lent their support to the restoration of the natural industry, but the crop season was too far advanced to secure an increased output in the near future. In fact, the area under cultivation in India in 1914 was 20 per cent less than the previous year. In 1895–96 exports reached their maximum at 187,337 cwt.; in 1902–3, a period following the establishment of the synthetic industry in Europe, the exports fell to 65,337 cwt.; while in 1912–13 they only reached 11,857 cwt. The United Kingdom has been most faithful among the principal consuming countries to retain the natural dye, although the country's requirements have been steadily curtailed. Among the strongest merits of the artificial dye were its more uniform character and the easier methods of using it. Moreover, the percentage of indigotin in the natural article was found difficult to determine. Wool takes more readily to the natural dye, but while the artificial article does not yield quite so bright an effect, its colour is constant. To encourage the development of the natural industry two proposals have been made: (1) to subsidise the industry in India, and (2) to restore the obligatory

natural indigo clause in all Government contracts. This clause is said to have been deleted under pressure of the German monopoly, combined with representations on the part of English dyers. The British Government bought up the Indian crop at the beginning of the war. The author thinks that any attempt to permanently bolster up the natural indigo industry will not meet with success. The only way of fighting the Germans in this industry will be by taking up the production of synthetic indigo.

Japan and China have also renewed their interest in the natural article. Latterly these countries had depended almost entirely on German synthetic indigo. Natural indigo production is one of the oldest industries of both China and Japan. Their own needs being great, they do not expect to be able to export any of the natural article.

Besides the competition of the synthetic article, indigo has had other rivals to face. The introduction of the direct cotton colours had little more than an initial effect on the consumption of indigo, because the direct blues of this class of dye-stuffs were not found to be nearly so fast as indigo. It is true that some direct blues are faster to light than indigo, and that some dark shades have the coppery appearance of that dye-stuff, but none have been found really fast to washing. Attempts have been made to increase the fastness of these dye-stuffs. The fastness to light was improved by an after treatment with copper-sulphate solution, and in some cases the fastness to washing was improved by treating the dyed material with a weak solution of potassium bichromate ; but still the fastness to chlorine was in few cases good. This fault was also evident in the case of indigo-blue dye-stuffs belonging to the basic class. Metaphenylene blue, Indamine blue, Janus blue, Indoine blue, and Diphene blue had certain good features, but were found wanting when submitted to the action of weak bleaching-powder solution. Naphthindone blue resembles indigo very much in aspect, reflex, and in being exceedingly fast to light, washing, and acids, but again the fastness to chlorine is not good. In order to increase the fastness of the direct cotton dye-stuffs, diazotising and developing on the fibre was introduced, and in this way many good imitations of indigo were produced.

Diamine blacks and blues, Naphthylamine black, and certain Benzo blues diazotised and developed with beta naphthol and other developers have been much used for producing indigo shades, but again the fastness to chlorine was not found as good as that of indigo. Alizarine blues and the alizarine cyanines have also substituted indigo in many cases. As regards the newer vat blues, there is no doubt that these colours are used for purposes for which indigo was formerly used; but the high price of these colours restricts their application. Moreover, these dyestuffs are found to "bleed" into white cloth (and more so than indigo itself) when boiled in caustic-soda solutions. This defect is particularly noticeable when the caustic-soda solution contains matter which has a reducing action. But of all the colours which have been used as substitutes for indigo from time to time, sulphur colours are the most important. Sulphur blues, which are exceedingly fast to light and washing, are now supplied by the different colour firms; in some cases the fastness to chlorine is fairly good, but this defect is their great disadvantage. The first sulphur blue was introduced by the Society of Chemical Industry, Basle, and was soon followed by Cassella's Immedial blue C; the patents for the two colours were owned conjointly by the two firms. Other sulphur blues were soon put on the market by the other colour firms. In America, sulphur blues are much used for warp-dyeing and for piece-goods. It is found, however, that these colours are not usually very fast to alkaline boiling.

In spite of the contentions of the makers of sulphur blues, there is no doubt that for producing indigo-blue shades indigo itself is the cheapest and the fastest dyestuff to use. At one time the firm of F. Bayer supplied patterns of cloth dyed with (1) indigo and (2) sulphur indigo blue, saying, "Please test the comparative fastness to washing and boiling." But the fastness of indigo depends largely on the method of dyeing, for if a strong vat be used and few "dips" given, the result is not so good as in the case of the employment of a weaker vat and giving more "dips." This remark also applies to Cassella's statement in their book on cotton-dyeing, that indigo loses in depth of shade every time the material is

washed, whereas some sulphur colours do not. If pieces of cotton dyed with indigo and with sulphur blue are exposed to the light, it is found that the former fades more rapidly than the latter; in fact, some sulphur colours improve in shade after a short exposure to the air. On further exposure, however, the conditions are reversed, and this distinction is apparent after a few days in summer or a few weeks in winter. Moreover, it is noticed that, although the indigo becomes lighter in colour, it remains the original tone, whereas the sulphur blue, whether it be after treated or not, fades to a greyish shade. Sulphur colours, unlike indigo, are not definite chemical compounds whose constitutions are known to chemists; and as most of them are probably mixtures, it cannot be expected that, as they are gradually decomposed by sunlight, the residual unaffected colour will be the same blue substance as composed the original dye-stuff. In order to emphasise the marked difference between indigo and sulphur blues under the action of light, the Bayer patterns mentioned above were exposed. After fourteen days both were still good in shade, but after forty days there was a considerable distinction in favour of the indigo; the indigo had remained a light blue, whereas the sulphur colour had become a dirty red-grey shade. The supporters of sulphur colours assert that the tests mentioned are too searching and that the fastness is good enough; but such statements do not satisfy the dyer, since for blouses, shirts, and other articles, colours are required which fade in an agreeable manner. Indigo alone does this, and many German dye-works have found this out to their cost, a return to the indigo vat being the consequence.

Vat dye-stuffs, which have been produced in large variety of recent years, are extremely fast and much used for woven goods. Thioindigo red was put on the market by Kalle & Co. in 1905, and since that time the Ciba and Algol colours have provided many other shades. These colours, along with the Indanthrene series, are dyed like indigo and are very fast, but because of their expense are not usually used for heavy shades.

CHAPTER IV

MERCERISING

Invention of the process—Hank-mercerising machines—Piece mercerising—Cooling of the lye—Recovery of the caustic soda—Recent scientific work on mercerising.

MERCERISING is a process of treating cotton with concentrated caustic-soda solution in order to give it a silky lustre and feel. The effect is not merely produced by the action of the caustic soda on the cotton, but either (1) the cotton must be kept stretched during the action or (2) it must be stretched to the original dimensions after the action. The soda causes the cotton to become transparent, to swell, and to shrink considerably; by resisting the shrinkage the lustre is produced, and, by washing the soda out of the cloth while the cloth is stretched, the cloth does not afterwards shrink when the stretching force is removed. Mercer in 1844 noticed that caustic-soda solution caused cotton fibres to become transparent, to swell, and to shrink; he made use of his observation in the production of "crimped" cloth by printing caustic soda on cotton cloth. Lowe in 1889 discovered that cotton in the stretched state became more lustrous when treated with caustic soda and washed while still stretched. He patented this method of lustring, but allowed his patent to lapse. In 1895 Thomas & Prevost repatented Lowe's idea, but the patent was disputed and became void. Experience has shown that for all classes of mercerising, caustic soda of strength not less than 55° Tw. should be used, that is, in the mercerising mangle, and the caustic soda should be kept as cool as possible during its action on the cotton. Numerous patents have been taken out

for adding different substances to the caustic soda to increase the shrinkage produced in the cotton, but all these have proved worse than useless. Progress in the art of mercerising has turned to the mechanical rather than the chemical side.

In all mercerising machines the question is the opposing of the force which tends to make the cotton shrink, for if shrinkage takes place the lustre suffers.

Cotton can be mercerised as (1) loose, (2) hank, (3) warp, and (4) piece. The mercerising of loose cotton does not seem to have yet advanced from the experimental stage. Different means have been suggested for gripping the fibres and thus preventing them from shrinking, but this has been found a difficult matter.

For yarn mercerising there are many machines. The principal German machines which the author saw at work were: (1) Kleinewefer's, (2) Haubold's, and (3) Bemberg's. The Kleinewefer mercerising establishment is said to be the largest of its kind in the world. Their hank-mercerising machine works on the centrifugal principle. The hanks are put over a perforated drum and enclosed by another drum. This drum is connected by a shaft to an exactly similar drum at the other side of the machine. Three hundred kilos of hanks are placed over each perforated drum, the outer drums are fixed over the hanks, caustic soda is admitted to the inner perforated drums, and then these drums carrying the hanks are made to revolve by means of the shaft. Centrifugal force causes the caustic soda to pass through the perforations of the inner drums, through the hanks and into the other drums. From these it passes back to the storage cisterns. The inner drums, being stoutly built, resist the shrinkage of the hanks, and in this way lustre is produced. The pipe is then disconnected from the caustic-soda cisterns, and water is let into the inner drums to wash (again by centrifugal action) the hanks. The hanks after being taken out of the drums are further washed in vats by hand. The caustic soda after being used in the machines, of which there are many in the same room, passes into a trough in the middle of the room and thence to a reservoir, where it is kept up to strength. The wash-water is used for

dissolving the solid caustic soda used for making up the solution in the reservoir. The time allowed for the action of the caustic soda on the cotton was five minutes, and the lustre produced was seen to be very good. It is important to note that the economy of the caustic soda was also said to be good. Most of their mercerising was done in the grey state. Messrs. Kleinewefer informed the author that they were not allowed to sell their machine in England, as their patent rights were bought by an English association of manufacturers.

The Haubold hank merceriser is very much used in Germany. It consists of two sets of heavy stretching rollers arranged in pairs, one over the other, and over each pair the hanks are placed. The distance between each pair is regulated so as to give the hanks a slight stretch, and then the rollers are caused to revolve. In this way the hanks are made to move round and round. The lower roller is then placed in a trough containing the caustic-soda solution, so that the hanks pass in and out of this solution many times. Shrinkage is prevented by the heavy rollers. After the hanks are thoroughly impregnated by the caustic solution, the caustic-soda trough is removed, and the hanks washed by jets of cold water while still stretched over the rollers. To economise the caustic lye, the upper roller is provided with a squeezing roller which, pressing against the hanks, causes as much caustic lye as possible to flow back into the trough. The machine is made very strong in order to withstand the great shrinking force exerted by the hanks when treated with the caustic soda. At the back of the machine there is a similar set of rollers which have the same position and are continuations of those at the front. The machines are made generally with twelve pairs of rollers, and have a capacity of from 500 to 1800 pounds of yarn.

Bemberg's have supplied their hank merceriser to Germany, France, and Italy. It is much like Haubold's in principle, the hanks being stretched over heavy revolving rollers; but there are four tanks or troughs, each containing two pairs of rollers. These tanks are joined together by pipes, another set of pipes connecting them with the supply of caustic soda.

In a very efficient American hank merceriser the principle is the same as that of the Haubold, but in this case the rollers move along longitudinal paths, the upper and lower rollers describing endless paths while carrying the hanks. The hanks are put on the rollers at one end of the machine, spurted with caustic soda while passing through the machine, and washed towards the end of the passage while still stretched. At the farther end of the machine the hanks are removed, so that the operation is a continuous one. The machine is the same at the back as at the front, and its removable glass sides show what is taking place within. The driving is very powerful. This machine is very suitable for large production and is used by one of the associations of manufacturers in this country. In the Cohnen machine the hanks are arranged radially on a revolving frame, in a somewhat similar manner to the method applied in the Klauder-Weldon machine. It was thought that the lustre would be increased by alternately stretching and releasing the hanks while saturated with the caustic-soda solution, but it was found that no better lustre resulted. With all these hank-mercerising machines it is found that some hanks have been less affected by the process than others, and in this case the hanks with the poor lustre are treated again in the machine.

With high perfection in mercerising machines, inventive skill has turned to the saving of the caustic soda. The hanks are well squeezed by auxiliary rollers and then washed on the counter-current principle. The wash-waters are sometimes used in the bleach-house, and in other cases they are evaporated and the caustic soda used again. Sometimes the first wash-waters are re-causticised and evaporated and the weaker wash-waters used for boiling purposes. Hot water and direct steam are sometimes employed to remove the last traces of caustic soda from the material, but it is said that by such a procedure special effects are produced. The swelling of the fibres is said to be less than when cold water alone is used for washing; consequently the threads occupy less space, and the material has a harsher feel.

The mercerising of cotton warps is performed on the

warp slasher or warp-dyeing machine, tension being produced by allowing the rollers to travel at different speeds.

Machines for piece mercerising may be divided into two classes: (1) those in which penetration is carried out on one machine, the cloth made into a batch and stretched on another machine; and (2) those in which penetration is carried out on one machine, and the cloth stretched on the same machine. At one time many machines worked by method (1), but nowadays most mercerising is done by the second method.

Many different ways have been tried for gripping the cloth and preventing it from shrinking under the action of the caustic soda, but in most cases it has been found that the stenter has to be finally used in order to bring the cloth out to the desired width. It has, therefore, become evident that the stenter is the best machine to use to keep the cloth stretched while under the action of the caustic soda. Cloth has to be turned out by the merceriser at the original width or at some definite width, and this necessity has led to the almost universal adoption of the stenter for piece mercerising.

At one works in the United States the author found cotton pieces being run in the rope form through strong caustic-soda solution, then washed and bleached in the usual manner. As a final operation the goods were stentered, and in this way a fair gloss was obtained, although the width was not fully recovered. One man attended to six mangles in which the cloth was saturated with the caustic lye, so that the labour cost was not high.

The most noteworthy machines not using the stenter for stretching purposes are Schwabe's and Jeanmaire's. In the former, the cloth is passed through caustic-soda solution contained in a trough, then between a pair of squeezing rollers, and finally on to a series of large and small rubber-covered cylinders. These cylinders are so arranged that the cloth is continuously in contact with one of their number, each cylinder tightly pressing against those adjacent. The cloth has thus little chance of shrinking, and the suction of the cloth against the rubber acts

the same direction. The cloth is washed while still ;tched by passing through troughs containing water, ;hat the washing is simpler than on the stenter. This ;hine gives a good lustre, and the shrinkage is said to ɔnly half an inch in a 27-inch cloth. There is no danger ;elvedge damages as on the stenter, and no danger of ducing a raggy cloth by overstretching. Schwabe's ;hine has turned out high-class goods for many years, . has sometimes been worked night and day. Judging n its structure and the number of rollers its initial ; must have been heavy. The machines of Ecob . Hasslacher are similar in action to the one just ;ribed.

When using the stenter for mercerising, the great nkage force, resulting from the action of the caustic a on the cloth, necessitates caution when fine cloths treated. In Schwabe's machine, where the tension is ributed over the whole of the cloth, there is no danger ;earing, but on the stenter the cloth is liable to give ' at any weak part. In the machine for which Jeanre took out his first patent, the cloth was held by ;rs, his device being similar in this particular to wabe's machine ; but afterwards pins were used to hold cloth. The author saw a Jeanmaire machine at work ı the firm of Koechlin Frères of Mülhausen. Its out- of fine cloth was five miles per day. The cloth passes ough the caustic lye on to the round surfaces of cylinders. ›se surfaces are covered with a large number of pins. se pins hold the cloth and prevent it from shrinking. ee cylinders are used for this purpose, the cloth passing r each. These machines are at work in Germany and erica, and are very suitable for the mercerising of fine hs. A new French machine stretches the cloth by ıns of a series of curbed bar expanders. The rinsing ı water takes place directly the cloth leaves the im- gnating mangle. The expanders are placed both above below the cloth, and the washing is on the counter- 'ent principle. The cloth is squeezed in passing from wash-box to another.

Гhe piece mercerising, done at Bemberg's of Barmen, at one time such a reputation that English manu-

facturers were anxious to ascertain their methods of production. They use the method of "batching" after impregnating with the caustic lye. A tight batch is made which after standing some time is taken to a stenter close by, passed through and at the same time washed, treated with acid, and again washed. The machines are made in various sizes, and with 6 H.P. they claim to mercerise 16,000 yards of cloth in ten hours. There was a large plant attached for cooling the caustic soda, but at the time of the author's visit it was not in use. In fact, ice-cooling plants, which were at one time used, are now seldom seen. Impregnating troughs, however, are made with a double jacket, so that if necessary the lye in the trough can be cooled by passing cold water through the jacket. In order to produce uniform mercerising it is necessary to keep the caustic soda at a fairly even temperature and not above 65° F.

It is impossible to obtain a good regular lustre on cloth which has not been thoroughly "boiled out" before mercerising. During the short time the material is in the cold caustic lye, unboiled cloth does not soak up the lye very well, and uneven mercerising results. This defect is usually shown up if the cloth is afterwards dyed or bleached, for the properly mercerised parts take up more dye-stuff and are more affected by the bleaching liquor than the parts which have not been thoroughly impregnated by the caustic-soda solution. Bad mercerising can be corrected to some extent by remercerising as previously mentioned in the case of yarn mercerising.

When one has experience of mercerising a certain class of goods on the stenter, one continually alters the machine until the best results are achieved, and it is only after many trials that perfect results are obtained. In this connection, it is interesting to recall the observation of Hübner and Pope that the greatest shrinkage takes place with caustic soda at 45° Tw. If lye of 55° Tw. be used, then on washing, that is at the first spirt pipe, sudden shrinkage takes place, or at least the tension is so great that careful watch must be kept. The author came across a machine in the United States which had been altered after repeated trials made by the managers. After impregnation in the ordinary

mangle, the cloth passed on to the stenter in the usual way. After a short passage, and when still far from stretched to its full width, the cloth was sprayed with the strong caustic lye used in the mangle. This arrangement was apparently to dispense with the use of two impregnating mangles, and the idea was to give the cloth another treatment with the caustic soda after the first dose had had time to penetrate the cloth. After this treatment the stenter gradually widened, and when the cloth was at its full width there was a break in the stenter. The cloth then passed between two squeezing rollers, and again on to the stenter, where it was washed. The manager stated that this arrangement was the best they had used, and they had tried many others. The cloth was certainly a long time in contact with the caustic lye, so that penetration was evidently good. The author thinks, however, that two mangles, as often used, would have had a similar effect.

Some works in the United States claim to have mercerising machines which are better than those generally known. Unfortunately these are not placed on view. It may be that they have some special devices for overcoming mechanical difficulties, but the merits of these machines are probably exaggerated. At one American works the author was shown everything but a new mercerising machine and a machine for dyeing sulphur colours. Both these were regarded as being of special importance, but the partial mobility of labour has probably revealed their " secrets " by now.

In the Gruschwitz machine for piece mercerising, the space taken up by the stenter is reduced by arranging part of it over the lye mangle. Only one [illegible] of the stenter passes wholly through warm water to wash out the caustic soda. The space required for the horizontal stenter is reduced in the Weisbach machine by adopting a vertical arrangement, the cloth being stretched on a circular chain stenter the two side-wheels of which have axles which are not parallel. The cloth after impregnation enters the clips where they are nearest together, and as the wheels revolve the cloth is carried round and stretched. The returns for Crefeld and district, at the time of the author's

visit, showed that the business of mercerising was not increasing and that they were losing some of their markets. The export to the United States had fallen off, as the Americans are now mercerising their own yarns, often buying them from England. At the same time, South America and East Asia had by increased demand partially made up the deficiency. Competition from all quarters is lowering the profits in this branch of the trade.

On the scientific side of the subject, work has been done by Hübner in contradiction of the early work of J. H. Gladstone on the action of caustic soda on cotton. Gladstone maintained that cotton combined with caustic soda, when immersed in a strong solution of that substance, to form definite compounds called "soda celluloses," while in weak solutions the caustic soda had no such action. Since that time the term "soda cellulose" has had a recognised meaning; but further work has tended to show that such compounds do not exist, and practical experience also points in the same direction. It has been shown that cotton absorbs caustic soda from all strengths of solution of that substance in water, and that there is no dividing line as suggested by Gladstone. Great interest was taken in the statement, which emanated from Germany, that cotton takes up considerably more caustic soda from a soda lye which has been saturated with common salt than from a lye of the same concentration containing no salt. It was stated that 100 grms. of cotton when immersed in a soda lye containing 12 per cent sodium hydroxide absorbed 8·4 grms. of the hydroxide, whereas from a 12 per cent solution which had been saturated with salt, as much as 5[illegible] grms. were taken up. It was thus thought that [illegible] supplant some of the caustic soda used in mercerising, and thus economise this expensive chemical. These statements were tested both on the large and small scale, when it was found that the effect of adding common salt to a 12 per cent soda lye was to decrease its mercerising power instead of increasing it. When the lye was saturated with salt, the mercerised cotton produced had not the same lustre or the same attraction for substantive cotton dye-stuffs as cotton mercerised under the ordinary conditions. Moreover, on allowing the cotton

to shrink while in the lye, it was noticed that the shrinkage produced was not so great when the lye was saturated with salt. Large-scale mercerising showed that the addition of salt to the lye had no practical value.

It is known that mercerised cotton absorbs more substantive dye-stuff and more moisture from the air than ordinary cotton does. The present author further showed (*Journ. Soc. Chem. Ind.*, 1909, xxviii. 188) that the moisture absorbed from the air by mercerised cotton increased as the strength of the lye used in mercerising increased, and was approximately proportioned to the amount of substantive cotton dye-stuff and of iodine taken up from solutions of these substances by the samples of cotton mercerised with different strengths of caustic soda.

As regards the testing of cotton for mercerisation, two methods were described by J. Hübner (*Journ. Soc. Chem. Ind.*, 1908, xxvii. 105) while the present author was his assistant and demonstrator in the Department of Dyeing, Manchester Municipal School of Technology. Of these methods the author has found the following very serviceable in practice. The pattern to be tested is first freed from finishing material and then immersed, for about one minute, in a solution of 20 grms. of iodine in saturated potassium iodide solution. It is then taken out and washed in a test-tube with cold water. Mercerised cotton retains the iodine for a long time during the washing, and remains of a blue-black colour, whereas ordinary cotton is soon washed white. The author uses the iodine solution over and over again, merely pouring it back into the bottle after use, so that the method is a quick one. In comparing degrees of mercerisation, by this test, it is necessary to have the samples in approximately the same physical state before testing. For instance, care has to be exercised in comparing two patterns one of which has been calendared many times and the other not calendared at all, for the form of the fibre has some effect on the absorption of the iodine, and also on the surrender of the iodine to the wash-water. After some experience, however, the test is a valuable one to use as a guidance. Cotton cloth is sometimes given the open-width bleach, the boiling being conducted with caustic soda of about 5° Tw. and after

schreinering the goods are sent out as mercerised cloth. The above test serves to detect such goods. It also shows any uneven action due to bad penetration and, when carefully performed, gives some indication of the strength of the caustic soda used for the mercerising.

CHAPTER V

BLEACHING

Development of the industry—Effect of chemistry—Efficient scouring—Continuous scouring—Open-width scouring—Electrolytic bleaching—Steeping of goods—The waxes of vegetable fibres—Bleaching without boiling.

BLEACHING is now a very different process from what it was in the eighteenth century. At that time a period of several months was required to bleach a piece of cloth, and in some cases cloth was sent from this country to Holland to be bleached on the grassy plains of that country. For instance, our linen manufactures were sent in the spring to Holland, where they were steeped in potash lye, washed, steeped in buttermilk, laid on the grass for several months, and finally returned in the autumn. Afterwards a very similar process became established in this country, and the goods were no longer sent to Holland. The introduction of sulphuric acid to replace buttermilk reduced the period of bleaching considerably, and the gradual adoption of chlorine compounds eliminated the long process of "grassing" for most classes of goods. The discovery of the bleaching properties of chlorine gas led to Berthollet in 1790 practically applying this gas to the bleaching of textiles. The method was introduced into England and Scotland, but it was not until Tennant used slaked lime for absorbing the chlorine, and thus manufactured bleaching powder, that chlorine compounds became extensively used for bleaching. By the introduction of chemicals the length of time occupied in the bleaching process for cotton goods was reduced from several months to a few days.

The industrial system of bleaching has really developed from the domestic system, that is in imitation of the actions of the housewife in boiling the clothes with alkali, washing them well with water, and spreading them in the sun to dry and bleach. Moreover, modern bleaching machinery has gradually been evolved from the domestic articles. For instance, the copper has produced the kier, and the domestic dolly tub, after itself being used in large-scale operations for a considerable time, was replaced by the wash-mills and, later, by modern washing-machines. Just as the introduction of chemicals shortened the period required for bleaching, so has the introduction of improved machinery caused a similar curtailment; but it is remarkable that, although the time required for the different operations has been very much reduced, the old process of bleaching has undergone little change. Details have received attention and some improvements have been made, yet the operations of liming, grey souring, ash boiling, chemicking, scalding, chemicking, souring, and washing remain substantially the same. Attempts have been made to curtail the long scouring operations, but these have seldom been successful. Latterly chemistry has been applied to the process itself, but it is remarkable that science has caused little change in the old process. The introduction of the caustic soda and resin boil has certainly replaced lime boiling for some classes of goods, but still the production of market whites is most often performed by the series of operations just described. Many good bleachers are ignorant of the science of chemistry, and as this science has affected them very little they are apt to belittle it and appeal to their empiricism. On the other hand, chemists are apt to ridicule empirical methods. But it must be remembered that a knowledge of chemistry cannot replace experience in the bleaching industry; there are many observations in practice which the chemist cannot explain, and he must proceed cautiously while paying due regard to the teaching of experience, instead of underrating the value of that experience. Textile fibres are complex bodies which are not thoroughly understood by chemists. Even pure cellulose, the basis of vegetable fibres, may be considered

as one of the enigmas of the chemical world, in spite of the large amount of work which has been performed on that substance. Nowadays, if anything goes wrong in the bleach-house resulting in "tender" goods, the cry is "oxycellulose." The chemist knows that oxygen and cellulose have been present during the tendering action, and he invents a word to explain the phenomenon, or rather to screen his own ignorance. The same may be said of the use of the term "hydrocellulose." The employment of such terms is an indication that chemists know little concerning the nature of cellulose.

Progress in bleaching has recently been principally on the mechanical side. Proper scouring is essential to good bleaching, and this is probably the most difficult of the operations of the craft. All bleachers know the difficulty of obtaining a really effective and thorough circulation of the lye through the mass of the fabric in the kier. Even in the best constructed closed kiers the liquor endeavours to force itself along the walls of the vessel, where the cloth is less tightly compressed and consequently offers less resistance. The remainder of the mass is not so well treated, and the result is that the bleach is lacking in uniformity. It is obvious that those parts lying in the direct path of the circulating lye will be bleached first, while those lying very remote will stand a poor chance. If, therefore, the boiling of the charge be interrupted after a half or one quarter the normal time for the operation, instead of the whole quantity of cloth being in a uniformly cleansed condition, some parts will be perfectly cleansed, others less so, and finally, there will be parts which are only superficially attacked by the lye. For this reason it is necessary not only to employ a higher temperature in order to obtain uniform bleaching, but also to prolong the time of boiling for several hours, whereas for the complete transformation of the impurities of the cotton only a short time is really required.

Various kiers have been introduced to ensure evenness in the treatment, and some of these have met with success. One type has a perforated pipe down the middle and a perforated cylinder lining the kier and at a short distance from its wall. Between the perforations of the inner and

outer cylinders the lye circulates instead of being injected through the usual non-perforated puffer pipe and showered over the top of the cloth. Kiers of this type the author saw under construction at the machine works of Haubold, Chemnitz and Gebauer, Berlin. In the Walsh-Jackson kier circulation is produced by means of a powerful centrifugal pump. The lye passes from the bottom of the kier into the pump, and then to a cylinder containing a coil supplied with high-pressure steam; the lye is thus heated while in the cylinder and is then forced by the pump back into the kier.

In all boiling operations the principal danger, as before stated, is that of uneven penetration, for in a kier containing two tons of cloth, the lye has to travel through many layers of fabric. This consideration has led to the introduction of scouring and bleaching in the open width. In this system the cloth is never made into the strand or rope form, but is treated the whole time at full width. It can be readily understood that this system gives uniform results and the damage to the cloth is less, since there is less chance of the cloth rubbing against objects in the way during the treatment.

The Jackson-Hunt kier for open-width bleaching consists of a cylinder with a horizontal axis and open at one end. The cloth in the form of a large "batch" is placed on a special apparatus and wheeled into the kier. The mechanism is so arranged that the batch can be unwound, passed over a perforated drum, and rewound into another batch. The cloth is, in fact, wound backwards and forwards in this way over the perforated drum during the scouring operation, and while passing over the perforated drum it is subjected to the action of a spray of caustic-soda solution, which is pumped from the bottom of the kier and thus through the cloth. There is a specially arranged driving gear to reverse the direction of winding of the cloth when each batch has been unwound. The contents of the kier are supplied with steam at a pressure of 60 lb. per square inch during the operation, and it can be readily understood that the caustic soda, at the temperature indicated by such a pressure, produces a thorough and very uniform scouring of the cloth. Before placing

it in the kier the cloth is passed through a special saturating machine. This machine consists of a large perforated drum placed in a tank of caustic soda solution. The cloth passes over this drum, and the soda is forced into it by means of steam which is blown against its surface. The cloth is then wound into the tight batch for placing in the kier.

Gebauer's of Berlin also build a machine of this kind, in which the cloth is saturated with caustic soda and wound backwards and forwards under steam pressure.

The Tagliani-Rigamonti patent continuous kier was invented by two Milan chemists, and the patent rights were secured by Bemberg's of Barmen, at whose works the author saw it in operation. Steam of low pressure is admitted to the chamber of the machine, which stands over the scouring solution, and at one side of the machine and outside the chamber a head of lye is thus created, which produces a kind of seal for the apparatus. The cloth passes through this seal, that is, through the head of lye between the pressure chamber and the wall of the vessel containing the lye, and is plaited down between two endless chains, which travel continuously over rollers. Between these chains the cloth is carried along, being at one time immersed in the scouring solution, and at another steamed by exposure to the pressure steam in the chamber. The complete operations consist of (1) immersion in hot soda lye, (2) steaming, (3) reimmersion in the lye, (4) resteaming, and finally, the cloth passes through the soda lye in the seal and out of the apparatus. The working of the chains mentioned suggests complications, but devices have been introduced to ensure against mishaps. The apparatus takes up little space, and for its size has a large capacity. The scouring liquor is kept thoroughly circulated by means of a pump, being drawn from the bottom of the kier and showered over the cloth, while it is passing through the kier. It is claimed that the apparatus can take up from 2000 to 8000 yards of cloth, and as the cloth, according to its nature, remains in the kier from one to one and a half hours, the machine can scour from 20,000 to 50,000 yards of cloth in ten hours. It is also claimed that the kier is more economical than the ordinary boiling

process. The machine the author saw and a few in Italy are the only ones known to be in use.

In the Welter (Mülhausen) continuous kier the inlet and outlet of the steam chamber are hydraulic traps, the former containing the scouring lye, while the other acts as a washing-box. It has, however, a small capacity for its size, even though the capacity has been doubled by running two pieces of cloth in together, that is, one upon the other. Moreover, the apparatus being large, it is necessary to keep the steam pressure low, and this is a great disadvantage.

The question of bleaching in the width is as important as ever, but the cost is higher than for the ordinary process of bleaching. The apparatus of Welter, Tagliani and Muntadas (Paris) give good results, the high cost being their principal disadvantage. The Jackson kier is excellent for heavy goods, but here again the cost of the apparatus is high. In considering the merits of these kiers it must be remembered, however, that the Jackson apparatus is different from the others in the sense that it does not work on the continuous principle, and that, unlike the other kiers, a high steam-pressure is used. The Jackson kier undoubtedly produces a perfect scouring of the cloth.

The Edmeston is another continuous kier. It was the first of its kind. It consists of one large tank open at the top, into which another tank is placed open at the bottom. Steam is admitted into the inner tank and causes a head of lye in the space between this tank and the outer one, the outer tank containing the scouring lye. The cloth is passed through this seal of lye between the two tanks, into the lye of the inner tank, and then, by means of rollers, it passes alternately into the steam of the inner tank and into the lye. Finally, it passes out through the other seal of lye. The Tagliani kier is a similar machine, except that it has one seal instead of two, and the cloth is passed along by means of chains instead of by means of rollers. The alternate steaming and lye boiling in the Edmeston kier is very effective in bringing about the scouring of the cloth. The cloth passes at a rate of from 30 to 50 yards per minute, according to the nature of the cloth. The pressure of the steam is of

course low, but high pressures and temperatures are not essential for good scouring. In fact, high pressures are used in practice in order to overcome the main defects of closed kiers, viz. want of movement. Nevertheless it is obvious that a kier of this kind is not suitable for all classes of cloth, but for some purposes the scouring produced is quite sufficient.

Of new methods of bleaching which have been introduced from time to time, that of Pick and Erban has received attention. They work the material in a 2-per-cent solution of turkey-red oil containing chlor-soda, and find this method successful for cops and spools. Turkey-red oil and castor-oil soaps have also been added to the scouring lyes to produce more uniform scouring.

Other bleaching agents besides bleaching-powder solution have been tried from time to time, but few have met with success, and bleaching powder still remains the only decolorising agent used to any great extent. Hydrogen peroxide gives an excellent bleach on cotton, but its cost is prohibitive. Sodium peroxide is used for special work. Sodium hypochlorite, made from bleaching-powder solution by adding soda ash and running off the clear solution, is a commercial article and is used in some works. It has the advantage over bleaching powder of being perfectly soluble, so that there is no danger of suspended undissolved particles in the solution. The present author maintains, however, that this danger does not exist in the case of bleaching-powder solution, if this solution be properly prepared, and if the steeping system of "chemicking" be used.

Bleaching powder is made in large quantities nowadays from chlorine gas, which is made from common salt solution by electrolytic decomposition: chlorine gas is given off and caustic soda solution is left behind. But if the chlorine gas be not allowed to escape, but is mixed with the caustic soda, a solution of sodium hypochlorite containing much common salt is produced. Special electrolysers have been devised to produce hypochlorite solution in this way. In one of these the electrodes are placed in a shallow trough, the space between them being taken up by a series of glass plates covered with platinum-iridium

wire and standing vertically and parallel in the trough. The salt passes into the trough from a cooled coil, and by the action of the current it is electrolysed to give a solution containing 3 to 5 grms. of active chlorine per litre. Another electrolyser uses carbon electrodes instead of the expensive platinum ones, and produces a hypochlorite solution containing as much as 15 grms. of active chlorine per litre. The author was at one time much impressed with the idea of making bleaching solution by the electrolysis of common salt solution, and even the failure of a bleaching company using this method did not shake his confidence. Later, however, he had an opportunity of testing the system on a large scale. An electrolyser of the best type was obtained and worked for many months, so as to give it a fair trial. The result has been that the electrolyser is now idle, several experiments having proved unsuccessful. From time to time there was trouble in working it, and the attention required was far greater than in the case of dissolving bleaching powder. It has often been stated that electrolytic bleaching liquor is not alkaline, but the author found that in all cases it was. By the decomposition of the salt, ions of sodium and chlorine are produced: the sodium ions react with the water to produce caustic soda and hydrogen, which escapes, and the chlorine reacting with this caustic soda produces the hypochlorite. This is the simplest explanation of the electrolysis; and chemical equations show that if all the chlorine unites with all the caustic soda produced the solution remains neutral, as it originally was. This complete union, however, depends on perfect circulation in the electrolyser. But in any case the caustic soda cannot get out of the electrolyser, and, as in practice it is found that some chlorine escapes, the result is that the caustic soda predominates, that is, the solution is alkaline. Donizelli stated that electrolytic liquor often contained so much caustic soda that certain stains were produced on some cloths, but in such a case as this the circulation in the apparatus which produced the electrolytic liquor must have been very deficient. Roscoe and Lunt, on making hypochlorite solution by the electrolysis of sea-water, found, on slightly electrolysing it and allowing it to stand,

the liquor decomposed rapidly. This decomposition was obviously caused by the weak solution oxidising the impurities of the sea-water, for stronger solutions did not decompose so rapidly, nor did weak solutions made by the dilution of stronger ones with distilled water.

On the large scale the author used bleaching-powder solution of 17° Tw., and such a strong solution contained a relatively small amount of lime. It was found that the bleaching properties of such a solution were identically the same as those of the solution prepared by the electrolyser. Moreover, on using sodium hypochlorite (obtained from bleaching-powder solution by adding soda-ash solution, the bleaching powder being in slight excess) it was found that this solution had the same efficiency as the bleaching-powder solution from which it was made, and also the same as that of the electrolytic liquor. A large number of bleaching tests proved this (*Journ. Soc. Chem. Ind.*, 1911, xxx. 185), and also their rates of decomposition in air were found to be the same. Among the advantages claimed for electrolytic bleaching liquor are (1) the bleached material is stronger; (2) the white produced is more permanent; (3) there is a saving of acid in the subsequent souring operation; and (4) there is less loss in weight. As regards these contentions, the author has shown (*Journ. Soc. Chem. Ind.*, 1911, xxx. 1295) that, no matter what agent be used for decolorising, the cloth must be well scoured, and that it is in the boiling operations and not in the bleaching proper that the principal drop in weight takes place. The tests of the author (*Journ. Soc. Chem. Ind.*, 1911, xxx. 185) showed that the cloth was not stronger or heavier when bleached by electrolytic liquor than when bleaching-powder solution was used. As regards cost of production, it was shown (*loc. cit.*) that with salt at 23s. a ton the cost of the salt alone was as high as the total cost of the bleaching powder, which the electrolyser seeks to displace. Similarly with current at ¾d. a unit, the cost of the electricity was equal to the total cost of the bleaching powder. But with cheap salt and cheap current, it might pay to produce bleaching liquor by the electrolytic method. Electrolytic liquor is very suitable for bleaching

wood pulp, raw cotton, cops and artificial silk, but for ordinary machine chemicking, the trouble is that no electrolyser produces liquor strong enough for this purpose (Higgins, *Journ. Soc. Dyers and Col.*, 1912, 254).

Another item of interest to bleachers is the effect which neutral salts have in retarding the action of the lyes during boiling. It has also been recently shown that dextrose retards the saponifying action of caustic soda. These facts point to the advantage of giving the "rotten steep" before boiling, in order to remove any mineral and other matter used in the sizing of the cloth (*Journ. Soc. Dyers and Col.*, 1912, 254).

The work of Knecht (*Journ. Text. Inst.*, 1911, ii. 22-29) on the constituents of raw cotton is of great interest to bleachers. In the first place he showed that cotton yarn, from which the wax had been extracted was stronger than the unextracted yarn. Since lye boiling takes away much of this wax, it is probably on this account that lye boiling is often found to increase the tensile strength of cotton goods. The present author further showed (*Journ. Soc. Chem. Ind.*, 1914, xxxiii. 902) the efficacy of the lime boil, followed by a soda-ash boil, in eliminating the waxes from textile fibres. The lime boil is not a mere survival of the days of empiricism; it is the best treatment for the bleaching of certain classes of goods. It was noticed, on plunging lime-boiled and soured cloth into hot soda-ash solution, that a large amount of matter was separated from the cloth, and its wax contents were considerably reduced; this fact is probably due to unsaponifiable and saponifiable (now present as fatty acid after the lime boil and sour) constituents of the wax existing together, the alkali producing a soap with the latter and at the same time removing some of the unsaponifiable matter, by disturbing it and producing an emulsion. The soap is produced quickly as the fatty acid is free (unlike the wax in the case of cloth not previously lime boiled), and a concentration of the soap in the neighbourhood of the unsaponifiable wax is produced. In support of this explanation, it is interesting to recall an experiment by Shorter (*Journ. Soc. Dyers and Col.*, 1915, 3), in which he showed that on adding a

solution of an alkali to a mixture of a mineral oil and a fatty acid, the emulsification was practically spontaneous. He explained this observation as being due to (1) the rapidity of the formation of the soap layer, and (2) the plasticity of the layer. We have these conditions reproduced in the case of the lime-boiled and soured cloth plunged into the alkali solution. Here the wax of the cloth consists of a fatty acid and an unsaponifiable wax, which for this purpose is similar to the mineral oil. Many methods of bleaching without boiling have from time to time been proposed, but the present author (*loc. cit.*) gives experiments in support of the contention that only by thorough scouring can good bleaching be produced. In fact, if the boiling operations be curtailed, then the impurities of the cloth, which are usually eliminated during the scouring, have to be decomposed by oxidising agents, and figures show that this is a much more expensive method of removal. At one American work cotton goods, principally crash and towels, were found to turn yellow and become "tender" in stock, and an explanation of the trouble was found after a consideration of the method of bleaching. The pieces in the dry state were steeped in bleaching-powder solution of 5° Tw. for one hour, allowed to drain for a short time, and then washed twice through an ordinary roller washing-machine. They were then mangled and dried. As to the actual cause of the "tendering" of these goods opinions may differ—chloramines may be suggested by some chemists as the cause,—but certain it is that the trouble arose because the goods had not been scoured before the application of the bleaching-powder solution.

Recently a number of substances have been introduced for use in the scouring lyes, in order to remove the waxy matters of the cloth. In some cases carbon tetrachloride, naphtha, and other volatile organic solvents are mixed with turkey-red oil, so as to form an emulsion which does not readily separate into its constituents. These preparations act very well in extracting the waxy matters from the cloth, but their high cost does not admit of extensive adoption. As a result of some tests performed by the author on the effect of hypochlorite solutions on these

waxes, it was found that they were partially decomposed and chlorine substitution products were formed, which yielded more readily to saponification than the original waxes. This observation explained the fact that on scalding after "chemicking," a large amount of matter is removed from the cloth.

CHAPTER VI

GERMAN AND ENGLISH FLANNELETTES

Use of raising—Cotton blankets—German production—Large-scale production—German and English methods compared—External and internal specialisation—Inflammability of flannelettes.

COTTON, unlike wool, does not grow on the back of an animal, and therefore cannot have the value of wool as a clothing material. Wool is a bad conductor of heat, whereas cotton is a fairly good conductor. But air is also a bad conductor of heat, so that in a "raised" fabric where a mixture of cotton and air is presented to the body the heat conducted away is less than when unraised cotton cloth is used. In short, raising greatly improves cotton as a clothing material. Very soon after arriving in Germany one encounters cotton blankets. These are made in beautiful designs, by raising heavy cotton cloths, and are found on most German beds. The demand for them is therefore great, and a special industry has arisen to supply them. München-Gladbach, the centre of this industry, is a severely industrial Rhineland town, which resembles our cotton city only in so far as it is principally engaged in an industry which deals with the cotton fibre. In and about this town are 400 textile factories employing 42,000 operatives, and also 111 engineering works with 4000 hands. Since there are only 62,000 people engaged in industry in this district, and as no other industry employs more than 2500 hands, it is manifest that textiles are the chief concern of the people of this town. The author visited factories engaged in the production of cotton blankets, and found them distinguished for their economic working. Water-softening plants were often used because

of the hardness of the water of the district, and were of prived economy. In the preparing-room of one works, Indian cotton and cotton-waste from Darwen and other Lancashire towns were seen being treated, in the first place, by machinery of a Manchester maker. Mule-spinning was used in the preparation of the weft-yarns, and only slight twist was given, because of the subsequent use to which the yarn was put. The cotton used for making the weft-yarns was dyed in the loose state, for if dyed in the cop the soft feel so essential for blanket-making is lost. The chief consideration is the preparation of a good soft oozy weft, and no pains were spared in the manufacture. A $\frac{5}{8}$-inch staple is used and spun by the condenser system. As many as six machines are used in the preparing, so as to produce a uniform yarn and in this way a uniform nap when the cloth passes to the raising machine. The consequence is that, on examining a German cloth, little unevenness in the yarn is apparent, whereas the irregular nature of some English cloths places the finishers at a disadvantage in attempting to produce a good raised article. At the Gladbach works mentioned above warp-yarns were bought from other manufacturers in Gladbach and Rheydt, and many coloured yarns from which grandrelle yarns were made were obtained from Saxony. In the weaving-sheds the Jacquard looms were seen producing a variety of patterns on a coarse, apparently hard, cloth. In the raising operation, the machines have to be carefully watched in order to produce a cloth of the right "feel" and weight. At the time of the author's visit, operatives for this class of work were difficult to get, and although the industry was in a flourishing state there was a scarcity of skilled workers. Belgians, and workers of other nationalities, at one time paid premiums in order to learn the business of such a works as described.

The cloth, before the actual raising, is submitted to a felting operation in a special machine, so as to make the cloth more solid and to improve the feel; a brushing and steaming machine is also used to improve the finish. By these processes quite a different article is produced than by merely passing the cloth through the raising machine. The superior finish of the Gladbach goods has been attributed to the good quality of the cotton used; but as this

is a mixture of Egyptian and Sea Island waste with special short staple Indian cotton, success seems to be due to more careful preparation of the weft-yarns. A uniform yarn is produced from cheap material and a uniform nap is obtained on the raised cloth. The nap obtained being short and uniform, the pattern is clear and the danger of firing is small. In England the cheaper flannelettes are raised quickly, a long fibrous nap being produced, which simply covers the interstices between the threads and causes a flame to run quickly over the surface of the fabric. The works described above had little trade with England, the home market being particularly catered for. Some shipping was done, and that through Hamburg. It was noticed that a Manchester firm of colour printers had been enterprising enough to supply their calendars to works in this district.

The specialised factories that have arisen in München-Gladbach were originally intended for the supply of the large home demand. Large-scale production, however, led to economic working, and after the home market had been supplied attention was turned to the building up of an export trade, which soon assumed large proportions. Before the outbreak of war, trade with England was increasing, and exports were being made to other European countries, as well as to South Africa, British India, Dutch East Indies, Siam, China, Australia, South and Central America, Mexico, Canada, and the United States.

In most cases a large home consumption leads to specialisation and to export. Sometimes the export trade is very profitable and temporarily raises the price at home, but in the long run the output increases, further economies are introduced, and the home price is in consequence reduced. A splendid blanket can be bought for four shillings at München-Gladbach.

In comparing English and German flannelettes the statement was made to the author that, with the improved machinery used by the German firms, it was possible to obtain a finish which could not be produced in England. It was also stated that during the last ten years the German machine had been protected by patents in England, whereas no such protection existed in Germany; that

high prices had been charged for the English machines and few improvements made; that German makers have been debarred from exporting their machines to this country, and as a consequence the English flannelette trade has remained stagnant. These statements, made by different persons, are certainly not a true representation of the situation, for two of the most prominent of German makers of raising machines have been shipping their machines to this country for many years. It is true that these firms had a dispute at one time over certain patent rights in this country, but when this matter was settled both firms exported their machines to us. German textile engineers have a habit of sending their sons to this country to receive some education and incidentally to exploit their machines; in this way a son of one of the machine-makers mentioned booked many orders in this country in 1906.

In comparing the flannelette trade in England and Germany it must be remembered, at the outset, that the industry has developed in different ways in the two countries. The German producers of flannelettes spin, weave, and raise their own material, but in England the manufacture is principally in the hands of three specialised businesses,—spinners, weavers, and finishers. Moreover, in Germany the spinning and weaving operations are specially adapted to ensure good raising, whereas in England the different agents for flannelettes on receiving orders for these goods often also receive stipulations as to whose yarn or cloth is to be supplied, and whose finish is to be given to the cloth. Certain English manufacturers produce cloths of world-wide reputation; customers will have these cloths and no others. Similarly, certain works have a reputation for their finishes, and these productions are likewise in demand. It is therefore manifest that the agent has seldom a free hand in the matter, and consequently the spinning and weaving of the cloth used for producing English flannelettes are not specially adapted to suit the raising operation, as they are in the specialised German factories devoted to this class of work. Moreover, were an English firm to adopt the German method and undertake all branches of the manufacture, they would have difficulty in finding customers unless the agents

received no stipulation as to the make of the cloth and the finish to be used for the production. But although the organisation of the English industry has disadvantages such as those mentioned, it must be admitted that certain advantages accrue from this development. The fact is that specialisation in this industry has become internal instead of external in this country. Specialised finishing works devoted to raising have arisen, and it is because of this development that the English finishers have been able to keep many branches of the flannelette trade entirely in their own hands. Cloths of all kinds pass through the hands of the English finishers, and consequently a large amount of machinery is required, since different cloths require different treatment in the raising operation. These machines have been constantly improved. The Germans treat fewer classes of goods, and therefore do not require such a variety of machinery.

The upright English-made machine has been adopted for certain classes of goods in this country, and it is said to give a closer and less inflammable nap than the usual machines. The 36-roller machine, which was first made in Germany, is now much used in England: a 38-roller machine has been made in France.

Returning to a comparison of the English and German industry we find that some Lancashire works have adopted the German method of putting the cotton through all the processes from the raw cotton to the finished cloth, but this is not general. Internal specialisation has become the practice of the English textile industry, because of the growth and variety of that industry. Manufacturers prefer to send their goods to outside finishers than to put down machines which they themselves could only run intermittently, whereas the specialised finishers, by keeping their machines constantly running, secure the most economic production.

In summary, we find the works at München-Gladbach using our machinery and our cotton-waste to produce an article which is in great demand all over the world. They produce this article cheaply, because of the large scale of production, and because they have specialised production for one class of article. In England we also specialise

in the production of flannelettes, but our specialisation has developed internally instead of externally. We have specialised in the production of a variety of flannelettes which no other country can excel. But it is because of the very nature of the development of our industry that we find it difficult to compete with the Germans in the one class of article which they make well. There is no doubt, however, that we could produce cotton blankets as well as the Germans, but we would have to do it in the same way, namely, by producing a good low condenser-weft (about 8's) and following up the manufacture carefully as they do.

In the past, however, the Germans were not our only competitors, for Dutch, Italian, and Spanish flannelettes have been sold in this country.

As regards the inflammability of flannelette, it must be remembered that it is only the low cloths with long irregular naps which are very dangerous; goods which are well raised and have a regular surface are very little more inflammable than the unfinished article. Soaking the cloth in certain chemicals decreases the inflammability, and this process has been gradually improved, but unfortunately those people who have not the sense to exercise care when their children are wearing flannelette articles, have also not the sense to pay a little more for the material which has been treated to make it non-inflammable. Hence the complaints of coroners. Moreover, the cost of the extra treatment required to make low flannelettes fire-proof, brings the price of the treated material very near to that of well-raised goods which, as before stated, are not dangerous to wear.

CHAPTER VII

THE INDUSTRY IN THE UNITED STATES

American conditions—Scarcity of labour—Large-scale production—Uncertainty of their industry—Lack of specialisation—Effect of the tariff.

We hear so much nowadays about American progressiveness and about manufacturers "scrapping" old machinery to make way for new, that any information concerning industrial conditions in America is welcome. The author's experience is that America has not much to teach us as regards the dyeing industry. Some machines were seen which are worthy of mention; a few of these have been devised because of the scarcity of labour, since some of the mills of New England could not, at the time of the author's visit, be run at their full capacity, because hands could not be obtained. Moreover, the enormous influx of foreigners does not supply all demands, for the poorest classes of labour are difficult to obtain, and in the summer months colour strainers and mixers are missing from the print-works because of the objectionable smells of acetic acid and other chemicals. In the manufacturing town of Passaic, New Jersey, which has a population of 35,000, every race of people is said to be represented, and costumes of all nationalities are seen in the streets, while in the New England cotton mills the Irish work-people are being gradually displaced by Hungarians, Greeks, and French Canadians.

The American cotton and woollen industries, and particularly the dyeing branches of these industries, are so different from ours that often different conditions and machinery are necessary. The American home demand is so large that the manufacturers are not so particular as

we are as to the material they turn out. American people all desire to be well dressed, and as different seasons of the year demand entirely different clothes, a huge demand arises. The calico-printing done is essentially that of the million, and the very best stuff is either imported or made by a few concerns. For instance, the head of one of the largest firms in New England said: "Here we print or dye a whole lot, put it on a train, and send it in the direction of California; it soon sells. In America there is a huge market, whereas in England you have different designs for different markets. Yet the English business is surer. A manufacturer knows how much the grey takes for bleaching, how much for mercerising, dyeing, printing, or finishing, and if he wants a turkey-red he knows how much he has to pay the dyer. Reckoning in this way he can arrive at the cost of placing the goods in his customer's hands, and be assured of his profit. But in our case, where we perform the whole of the operations from spinning to finishing, we have to wait until some period of the year when the audit tell us our fate. In America we aim at turning out the stuff cheaply and quickly." Most mills undertake the whole of the operations from the raw material to the finished article, nor does the industry show much sign of modification in this respect. Instead of specialising internally we find the mills extending their scale of operations. For example, the Gera Mills, Passaic, New Jersey, have begun to spin their own yarns for the making of woollen piece-goods for which they have already a reputation. In New England some specialised works are arising, owing to the rather highly developed state of the industry in this part, and managers are hoping for a time when goods will be dyed on commission, as is done in this country. Specialised bleach-works and dye-works have been installed at Fall River, Lawrence, and other places, and English conditions have ensued at New Bedford in the separation of the spinning and weaving branches of the industry.

Moreover, the extent and homogeneity of the American market has led to the production of large quantities of the same material, and has thus brought about the economies incident to large-scale production, and at the

same time made their industry of a particular and unique character. America is too occupied with the development of her own market for textiles to give much attention to the export trade; but this development is bound to take place, and already some of the New England print-works ship some very fine prints. With the change and increase in the variety of human tastes everybody has sought the best material, and this circumstance has led to the creation of a large class of good imitations in order to meet all purchasers. It is said that in this class of work we are behindhand, and pointing to the foreigner we are urged to adapt ourselves to the change of circumstances. This supposed backwardness in the art of imitation has not, however, always been one of our failings, for, to the former possession of this trait in our characters, America owes much of the fame of her cotton goods in Eastern markets. In the 'sixties we used to send cotton goods to China, which contained more filling than they did cotton, and in some cases they were known even to crack. China clay and other fillings were employed to cater for appearances and also to save cotton, and so much filling was demanded that the finishers complained that the treatment was ruining their machinery. Moreover, mildew was a frequent occurrence in these goods, as at that time an antiseptic was not used in the finishing mixings. After the Civil War, American manufacturers sent out goods which contained very little finishing material, and very soon American drills and sheetings became of world-wide fame. Nowadays we send similar goods and not heavily filled cloths to compete in the same markets.

The high American tariff has in many cases caused foreign manufacturers to establish branches in the United States, and often the machinery and hands to operate it have been imported. But after a time some of these branches have become Americanised and changed in character. The Gera woollen mills is a branch of the firm at Gera, Germany, the employees, machines, and methods having been brought over from the parent works. Titus Salt's of Saltaire have a branch in Bridgeport, Conn., which is in a further state of development, having become

an American concern. Originally it had English employees, but now only the principals are English by birth. Linen thread mills have also been established, which import their material from the parent works and thus escape the tariff.

CHAPTER VIII

LOWELL, LAWRENCE, AND FALL RIVER, MASS.

Lowell—The town and its industry—Merrimack Manufacturing Company—Hours and conditions—Turning to finer work—Production of machines—Employer and employed—Hamilton Manufacturing Company—Arrangement of works—American worker—Lawrence and its industry—Pemberton Works—Pacific and Arlington Mills—Fall River—Water supply—Fall River Bleachery—The drying of cloth—Barnaby Works—Bridgeport, Conn.—Salts Manufacturing Company—Klauder-Weldon dyeing machines.

THE town of Lowell is brighter than most English manufacturing towns; it is nicely situated in the country, and abounds in amusements of the best kind. There is also a splendid library and a technical institute. The population is 100,000, and there are forty mills engaged in different branches of the textile industry. Bleaching, dyeing, and finishing are usually performed by the big works themselves, but there is one specialised bleachery. Lowell is well served by two railroads.

The Merrimack Manufacturing Company have the largest mill in Lowell. They manufacture plain and fancy cotton goods, linens, towels, and corduroys. The capital of the company is $4,400,000, and 140,000 spindles, 7200 looms, and 21 printing-machines are used in the works. The manager of the printing department came from Manchester, England, and thus was able to compare English and American conditions in the dyeing and printing industry. The firm willingly allowed visitors to go over their works. There was a combination of manufacturers allowing servants of the different works to visit other works in the combination, and this arrangement was found to be to the mutual benefit of the works

themselves. A man might get an idea from visiting a neighbouring works, and he might use this idea advantageously, without in any way hindering the works from which he obtained the idea. This combination was really a pool of knowledge, and the manager of the Merrimack Works thought it was the best way of conducting industry, since it was useless to attempt to keep secrets. But all the works do not grant the same concession to strangers, as regards looking over their plant, and some firms are becoming very strict and exclusive. For instance, there are two print-works in North Adams, Mass., where rivalry is so bitter that the operatives from one works are not allowed to discuss business matters with the operatives from the other. This behaviour, however, was not approved by other employers in the industry.

In the Merrimack Works no secrets are allowed. All the mixings used in the different departments are known to the principals, since they consider that they know more about the dyeing, printing, and finishing of their own cloth than, say, a foreman newly introduced from abroad. Some time ago they had a case of an indigo-dyer who refused to give full particulars of his mixings and methods. This man had to be discharged. It is essential that the managers of a works should have full information regarding all the separate processes of the works so as to trace back any faults which might occur, and also to see that as little waste as possible takes place. At the Merrimack Works a book in each department records what is going on therein. The colour-mixing is of course an important part of the industry, and no dyer is allowed to mix his own colour. Moreover, the dyer is not allowed to take any part in the buying of the dye-stuffs, and on receiving his dye-stuffs he is often ignorant as to the firms which have supplied them. The manager said he had never met a dyer who could mix colour; they usually added the dye-stuff to the bath in pinches instead of taking the greatest precautions to ensure perfect solution.

In the colour-mixing room there was a strong smell of acetic acid, and, as stated before (p. 49), it is because of this unpleasantness that the management have the greatest difficulty in the summer months of getting men to work

in this department. In fact, the scarcity of labour does not only apply to such low-grade labour, but is evident in all branches of the industry. For instance, part of the weaving-shed at the Merrimack Works was shut down at the time of the author's visit because of the lack of operatives, and an American professor told the author that, for the same reason, he could not get a fence put round part of his garden. Yet in all the open spaces of New England manufacturing towns, and particularly in Lawrence, men are seen lounging about and apparently escaping the work.

At the Merrimack Works the working hours are 10½ a day, and a stoppage is made at noon on Saturdays. The manager said that the most successful works were those which employed the highest-paid hands, had the works scientifically managed, and used the latest machinery. The Arnold Works at North Adams, Mass., is the best print-works in the country, and their fine prints command a foreign market. They are an old-established works, which have specialised in fine prints, and have been very successful. Their success, he said, was due to specialisation, the employment of the best hands in the country, good management, and the use of the latest machinery. Only the firm with the latest machinery could survive in the long run, and if a firm makes big profits, these should not be all paid away in dividends, but a portion put to reserve, in order to ensure even greater profits in the future. The best investment is the "scrapping" of inefficient machinery to make way for later inventions.

The manager then spoke of the advantages of specialisation, and this development he regarded as the true road to success. Schoenhof, in his *Economy of High Wages*, states: "An English paper-mill boasts of making one hundred and sixty varieties, whereas an American mill confines itself to one, and whereas a Salford mill weaves many kinds of cloth they (Americans) treat of few." There is thus a certain kind of specialisation in America; but the manager of the Merrimack referred to the English kind of specialisation, namely, that in which a works devotes itself to one class of operations only.

At the Merrimack Works they recognise that they are treating too many kinds of cloth. They have a reputation

for their coarse goods, having made these since 1823, but they have found that treating these goods and their fine goods with the same machinery did not pay. They are consequently going in more and more for the finer goods. This trade was the more profitable, and the price of cotton had not so much influence as it had on the cost of production of the coarser goods. At one time the Southern growers combined, and would only supply a certain amount of cotton. The manufacture of their coarse cloths was thereby severely affected, and they had to shut down part of their mills. It is thus seen that American industry is affected as ours is by speculators in cotton. Moreover, while at Chemnitz the author found the Germans much interested in the presidential election in the United States, as they considered this event decided to a large extent the stability of the cotton market.

As regards his own department, the manager at the Merrimack said, that if they took other people's cloth and printed it at so much per piece they might be more prosperous and more certain of some profit. At present they were making an effort to turn out finer counts, and thus to lead to fine prints. Although England has many more spindles than America, yet the latter country consumes more cotton, a state of affairs due to the fact that English yarn has grown finer and finer. Long training and hereditary skill, among other things, accounted for this advantage of the English, and he thought time would bring England and other countries nearer together, certainly England and America closer, and, he hoped, Bolton and Lowell.

At this works there is a mercerising-machine (described on p. 26), and also a machine for giving a slight mercerised finish (p. 24). These machines were built in their own shop, where they employ many men and make most of their own machinery. This system of attaching machine-shops to the works was also found in Germany, and serves to show how much more specialised the textile industry has become in England. Those exploiting industries in new countries can speak of the annoyance caused by the lack of machine and other subsidiary industries, and, in order to ensure success, these subsidiary industries have to be built up along with the primary ones. But specialised

machine-shops are now arising in all districts of the United States, and gradually the conditions are coming to resemble those existing in this country.

They have a Birch (English) soaper and also many copies of this machine, a Mather and Platt ager, and some of the same firm's printing machinery. They are gradually introducing their own machines in place of the imported articles. Beetling was done at one time, but was found too expensive a finishing process for the class of goods sold in their markets. Some of their stentering machines were enclosed in glass and wood frames. These enclosures confine the heat, but at the same time they do not allow the moisture to escape freely from the cloth which is drying on the stenter. But an important point is that they protect the operatives from the heat, and thus ensure their regular attendance. In other stenter drying machines steam-pipes were placed directly under the travelling cloth, and the moisture driven off the cloth was allowed to escape freely. The pipes were enclosed in order to confine their heat, but the cloth was freely exposed. The hot-air drying arrangement was also in operation, but the second system mentioned, namely enclosed steam-pipes and exposed cloth, was found to be the best.

Few jiggers were used in the dyeing department, most of the dyeing being done by padding. A large amount of para-nitaniline red and naphthylamine claret had been done by them, but there was little demand for these goods at the time of the author's visit. Turkey red was too expensive for the American market.

In the past the Merrimack Company have had much trouble with their operatives, but manufacturers have combined and taken a firm stand on some occasions. The manager said that if they once yielded, they would have little peace afterwards. By agreement they shut down all the mills immediately one mill's hands strike, and thus all Lowell is idle. Then the operatives soon surrender, and resume on the old conditions. There was a strike of engravers at one time, and the Merrimack Company, instead of submitting, sent all their rollers to England to be engraved. This action cost them $300,000, but they gained in the long run.

Referring to engraving, he said they were forced to keep a large number of rollers in stock, but, owing to the high price of copper, they took risks and turned rollers down even when there was a possible chance of a repeat order. English firms, having more designs, have to keep a bigger stock of rollers. The Merrimack Company, like other similar firms, makes its own pattern-cards and does its own making-up and packing, but they have outside selling agents. At one time the operatives were mostly English and Irish, but now they are of many nationalities, Greeks and Armenians predominating.

The operatives are encouraged to work up to their utmost capacity. At one time, if a workman returned more than the usual amount of work, the foreman used to stop the excess; but this procedure has been stopped, and the men are allowed to turn out as much work as they can. The machines are run at a high speed, because it would not pay to run them slower. Thus, in the printing department the machines never stop running from 6 A.M. to 5.30 P.M.; the printer stays by the machine all day, not even leaving it for meals, which are taken at irregular intervals. The American workmen run their machines at the greatest capacity, and endeavour to get through as much work as possible; whereas in England, so the manager said, the Trade Unions restrict output and hinder development. He said the men were too much in league in England, while in America the slightest united movement is detected, and, whenever possible, prevented.

Yet it is difficult to strike a happy medium between the cause of labour and that of industrial development. It must be remembered that other countries are developing towards our position as regards the power of labour, and in the near future it will be found in America that turning a whole town idle from time to time will not solve all the employers' troubles. From time to time we have had instances in this country of the tendency of labour to hinder the introduction of new machinery. This policy is of course a bad one for all concerned, for if we are to keep our industrial position the efficacy of new machinery must be recognised. The development and progress of our industries during the last hundred years have been truly

marvellous, surpassing by far the progress made in the previous history of the world, but the rapid advance of the United States and of Germany in recent times has perhaps been even more phenomenal. These advances have been due for the most part to new inventions on both sides of the Atlantic, for in countries where labour-saving machinery has not been developed, man has been found in the lowest and the most humiliating state of degradation, and such would still have been his condition throughout the world without its introduction. As regards our own position in industry, there is some truth in the words of the late Sir R. Giffen that there is enough indolence and routine mismanagement in English manufacture to make it desirable in every way to have the stimulus of foreign competition applied.

Returning to Lowell, we find that textile manufacturing companies are granted land at reduced rates in order to encourage industry. As regards the arrangement of the buildings, at the Merrimack Works it was noticed in the bleaching and finishing department that it was the system to devote each floor of a building to a definite set of operations. The actual bleaching was of course carried out on the ground floor, then the cloth passed to the first story, where it was dried and finished, and finally passed to a third floor, where it was lapped and packed. This system is evidently a good one, and is also adopted by a number of German works. At one American works the transference from one floor to another was facilitated by a series of elevators.

The Hamilton Works at Lowell is one of the biggest concerns in the town. The company has a capital of $1,800,000, and has 110,000 spindles and 3000 looms devoted to the manufacture of prints, ticks, flannels, stripes, and shirtings. In the dyeing department mordants were seen being padded, and the cloth afterwards dyed on the rope-dyeing machines. Jiggers are very seldom used in the United States, as the dyeing is principally that of large lots, for which purpose continuous machines are more adapted. Moreover, this class of production is economical of labour, as the machines do not require to be continually reset. For instance, in printing a large number

of pieces of one pattern the same time is occupied in setting the machine as in printing only a few pieces of the same design. The hours are the same as at the Merrimack Works, but they stop their spinning and weaving departments from 12 to 1 each day. On Saturdays all work ceases at 12 A.M. The printer thought that the American worker did not actually work as hard as the Englishman, and as he had worked for a long period in a print-works near Manchester, he was capable of forming a judgment. He said they had few disputes with their hands. The foremen were often English, but the lower classes of labour were principally recruited from new immigrants, and consisted for the most part of Southern Europeans. French people worked in the spinning and weaving departments, but not in the dye-works. At this works automatic counters were noticed in the lapping and packing rooms; girls sat at these machines, and recorded the lengths as they were called out to them. The machine recorded the addition of these numbers, and gave other information regarding them.

Lawrence, situated like Lowell on the Merrimac River, is engaged principally in the woollen and worsted industry, but some cotton is treated, just as is the case in Yorkshire. The Merrimac River has a fine fall at this point, and provides part of the electric power required by a splendid double line of mills on its banks. These mills are said to be the largest in the world, and certainly no place has as great a concentration of factories as exists along the sides of the Merrimac at this point. Lawrence has a population of 63,000, and over twenty mills engaged in textile manufacture. There is one specialised bleachery and one dye-works for woollen and worsted yarns, that is, one works devoted only to dyeing.

At the Pemberton Works warps and raw cotton were seen in process of dyeing. The superintendent said hank-dyeing was declining, as it was too expensive a process. Warp-dyeing is more rapid and requires less labour than dyeing in the hank form. Warps were being dyed with logwood and with iron buff at the time of the author's visit. The machine used was of the ordinary type, the warps passing over rollers through the solution and then between rollers before going into the next box. The same

machine was used for dyeing with sulphur colours, and a sulphur indigo-blue was seen giving a bronzy indigo shade. The manager said they used very few different colours, but large quantities of each. There were two machines in use for dyeing raw cotton. In one, the raw cotton and the dye-solution were fed into a tank, which overflowed into a long cistern. By means of a series of big rakes, which were driven by machinery, the cotton was dragged through the dye liquor, and finally drawn between two quickly-driven rollers. The speed of the rollers sent the cotton into a basket, from which it was taken and treated preparatory to spinning. The raw cotton was thus fed in at one end of the machine and came out dyed at the other. The arrangement is similar to a machine often used for wool scouring. The Klauder-Weldon raw-stock dyeing machine was also in use. In this machine the cotton is placed in a perforated cylinder, which revolves on another concentric cylinder containing the dye liquor. By this method it is manifest that better dyeing could be produced, but, unlike the other machine, the process is not a continuous one.

The Pacific Mills and the Arlington Mills in another quarter of Lawrence were visited, and found to have laboratories directed by trained chemists; the chemist at the former works had lectured on printing at the Massachusetts Institute of Technology at Boston.

Fall River, well situated at the mouth of the river of that name, is the most important cotton town of the United States, and contains a large proportion of that country's spindles and looms. The river is so named because of its rapid fall, and power obtained from this fall is utilised in the mills. The population is over 100,000, and sixty mills are engaged in textile manufacture. Of these, two are print-works, one a bleach-works, another a dye-works, and one works does both bleaching and dyeing for the trade. Of the remainder of the works, some dye and bleach for themselves. There are more works in Fall River, which have devoted themselves, as stated, to particular branches of textile manufacture, than in any other district, this development having resulted from the growth of the industry in this town. It

is seen that as the industry has developed, specialised works have arisen just as they have arisen in this country.

The capital of the mills varies from $2,000,000 at the Fall River Ironworks (a textile manufacturing concern with a peculiar name) to as low as $20,000. Water for the mills is obtained in this district from small lakes, and it requires no treatment before use.

The Fall River Bleachery, which specialises in the bleaching and finishing of cotton piece goods, obtains its water from one of these lakes. The capital of the Company is $600,000, and the daily output 35 tons. Only low-pressure kiers were used for all classes of cloth. Gas or plate-singeing machines were used according to the nature of the cloth. For instance, a cloth, which was to be afterwards coated with varnish for making insulating material, was singed on both sides by means of an arrangement of four singeing cylinders. Blue dye-stuffs were used for tinting, and in one case a mixture of a basic blue and saffranine was used for the goods of a maker of cheap collars. As regards drying cylinders, the manager thought the best arrangement was to have the first cans arranged horizontally and the last vertically. If all were horizontal, too much space was taken up; and if all were vertically arranged, the steam escaping from the damp cloth below affected the dry cloth above. In order to save more space the "cell dryer" had been introduced. This machine is on the same principle as a make used at one time in print-works in this country. It consists of a big box, which contains a large number (about fifty) of small copper boxes or cells. These cells contain high-pressure steam (about 15 lb. per square inch), and by means of rollers driven by a motor the cloth is made to pass over the cells. The machine is small and compact, so that not so much heat is lost by radiation as in the case of the much larger drying cylinders. The cells may also be fitted to printing-machines in order to dry the cloth and the blanket simultaneously; in this case they are arranged at any convenient place, and do not take up much space. During the passage of the cloth through the "cell dryer," which is used for drying bleached or dyed cloth, there is so much friction between the cloth and the cells that, on putting

one's finger to the cloth as it emerges from the machine, an electric spark passes. The machine is suitable for the American industry, where large lots are treated, but for smaller quantities of dyed goods it might be necessary to clean the machine after different colours are run. Yarn can also be dried on it. Englishmen employed at the Fall River Bleachery said they ran their machines much faster than we run ours.

At the Barnaby Works, Fall River, weaving, dyeing, bleaching, and finishing are performed, cotton and silk goods being produced. Yarns were bleached and dyed before weaving, and were always treated in the warp form. Warp-dyeing with indigo was done in the usual way and "chemicking" in vats, the bleaching liquor being circulated by pumps. Dyeing and bleaching were only performed for their own weaving sheds, which were adjacent to the dye-house.

At the Salts Manufacturing Company at Bridgeport, Conn., the principal objects of interest were the Klauder-Weldon dyeing machines for hanks. This machine is found in a great many dye-works in the United States, and is very suitable for their industry. It consists of a cylindrical vessel, containing the dye liquor, and a drum, which carries the hanks and revolves in the dye liquor. On the outer rim and at the centre of the drum are a series of sticks, which carry the hanks so that they are radially situated to the drum. During the revolution of the drum, the sticks, on which the hanks are placed, consecutively come into contact with a metal strip attached to the outside of the machine, and by certain mechanism the hank is caused to move round on the sticks. In this way all parts of the different hanks come into similar positions consecutively, and thus even dyeing is ensured. The machine is enclosed, so that when the hanks are out of the dye liquor during the movement, they move in an atmosphere of steam. The dye liquor is first used cold, and then gradually heated up while the drum slowly revolves. When dyeing to shade, there is an arrangement for lifting the whole drum out of the dye liquor so as to test a portion of the dyed goods. Dyeing to shade is difficult with this machine, but is said to become much easier after experience.

The dyer at the Salts Works said the machine lasted until the metal wears away, and that it saved a considerable amount of labour. When once started it required little attention. The Klauder-Weldon machine is of course more suitable for large than small lots, and is for this reason not well adapted to the needs of the American industry. It is built for batches of from 100 to 400 lb. of yarn, and is specially adapted for certain classes of dyeing, as all colours cannot with advantage be dyed in it. For instance, it is difficult to dye basic colours, as there is a tendency towards unevenness; and for first-class work, as self shades, dyeing by hand has to be resorted to. Another disadvantage is that the machine is difficult to clean, so that a change from one colour to another is troublesome. It is most economically used when large quantities have to be dyed one shade. Developed blacks were being dyed at the time of the author's visit. Many of these machines have copper linings, and this circumstance has prevented their use for the dyeing of sulphur colours. To remedy this, machines have now been constructed with iron walls. In these the liquor is filled to the top of the machine, so that the yarn is immersed in the dye liquor the whole time. The pumping of the liquor is troublesome, but otherwise the machines are said to work well.

The Salts Company's works have also a warp-dyeing machine, which is used for dyeing developed blacks; also a five-colour printing-machine. There is a small laboratory attached to the dye-house, in charge of a qualified chemist, who had been at Yale University, and had also spent some time at a German colour-works.

In the United States the print-works and even the spinning and weaving mills sometimes close down during the hottest period of the year. Because their chief market is their home trade, and as there is little buying during the summer months, the manufacturers sometimes find it better to cease producing and sell their accumulated stocks. The work-people are given a compulsory holiday, and find some temporary employment during the time the mills are idle. In this country, because the bulk of our trade is for export, our print-works are better employed than those of other countries.

CHAPTER IX

CONDITIONS OF LIFE IN THE INDUSTRY

Injurious conditions in dyeing—England. Germany and America compared—The power of the workmen in Germany—The development in America—Wages in the three countries—America's high wages—Short hours—The German workman and the American.

In some branches of the dyeing industry the conditions are injurious to health. For instance, during the polishing of yarn and when yarn dyed with chrome colours is shaken, the fine particles of dye-stuff, which are sent into the air, are harmful to people breathing that air. The aniline vapour produced in some operations is also very harmful, as are the vapours given off during Prussian-blue dyeing. Again, the action of "chrome" on the skin during chrome-dyeing might be mentioned.

The operatives in all countries are protected to some extent, and in this country the regulations are the most stringent of all. Precautions must be taken by our dyers when engaged in some of the operations above mentioned; rubber gloves must be worn during chrome-dyeing, and good ventilation must be ensured during aniline-black dyeing. In America, high wages are apparently some consolation for evil conditions; but to enforce restrictions seems a safer policy, since "whitewash and machinery fences cannot be spent on drink or wasted in betting."

Cleanliness is of the greatest importance in the industry under consideration. A large firm of engineers have their machines painted white and the walls of the workshop whitewashed continually. They say it pays them, because of the good effect on the workpeople. Much has been said against modern works having inside walls of white

ules, but probably the initial expense is justified when all the advantages are considered. Some American works employ youths to go continually round the departments scrubbing and dusting.

In the larger and newer works the conditions under which the workpeople toil are much better than those prevailing in old works. In some parts of Germany dyeing is carried on in the most wretched places, whereas in other parts the conditions are much better. At Chemnitz and Elberfeld the dye-works are arranged along the respective rivers, and a trip along these is a revelation. At the former place some of the works have been transformed from old houses; the office and drying departments are in the house part, while the backyard is covered in and used as the dyeing department. The latter section is very dirty and full of steam; dye-baths, hank mercerisers and bleaching apparatus all seem thrown together, and the small space presents nothing but a mass of disorder.

The manufacturing towns of Germany stand in vivid contrast to those in which manufacture is not so vigorous. When the industry is a new one, some attempt is made to organise it with regard to sanitation and beauty; but in old industrial towns the conditions are far from pleasant.

At Barmen and Mülhausen visits to works showed entirely different conditions from those above described. At one works the absence of steam from the dye-house was noticed; it was driven through ventilators in the roof by means of a current of warm air rising from grids in the floor. The works were well ventilated, and had plenty of space and light. In the particulars given above, the subsidiary dyeing industry has developed in somewhat the same manner as the primary textile industries. "The safety, the cleanliness, the ventilation in all the factories show that agitation and legislation, supported by the humanity of employers, as well as the self-interest of workmen, have raised the sanitary conditions to a higher level in the factories than in the homes of even our modern workmen." The above has been said of the cotton industry, but even in this industry we have some survivals of the old conditions. Similarly, in the dyeing branch the first

examples given may be taken as corresponding odious survivals.

Similarly in America, in the oldest industrial districts the conditions are the least pleasant. In some cases the dye-house was considered as a mere shed out of which the steam escaping from the dye-baths had to find its own way; in other cases machines were crowded together and surrounded by pools of water. But again, the more modern factories are well built and well kept. A comparison between English and American industrial conditions is difficult: an Englishman visiting America in the summer months finds the conditions disagreeable because the intense heat of an American summer accentuates the defects. But the fact that America has, in some cases, such good conditions is a bad thing for this country, in the sense that some of our best workmen are being attracted by the higher wages and better conditions, and their skill used against us. There is, however, little to choose between the conditions prevailing in the works of England and of New England, for the simple reason that the Americans are following in our footsteps as regards the industry and as regards the legislation affecting it. In fact, all the countries are learning that their wealth is to be found in the quality of their citizens, and that improving industrial conditions is a most rational form of patriotism. Nevertheless, although all three countries mentioned possess both bad and good industrial conditions, yet Germany in the instances mentioned possesses the worst conditions of all.

As regards industrial organisations, it is well known that the trade unions in Germany and America are not so powerful as those in England, yet they are growing at a rate which is alarming to many people in those countries. In Germany the workmen take more interest in political effort than in carrying on strikes. The people are overawed by the police, who have the right to close their meetings and interfere in other ways. Strikes are not of frequent occurrence, for the employers are so strong that the workmen perceive the futility of standing out. Occasionally, however, strikes occur. For instance, there was a dispute, lasting a few days, at the Badische Anilin

und Soda Fabrik (the largest colour-works in Germany), at the time of the author's visit there. The men won and gained a substantial increase in wages.

In the United States agitation is more in the way of spasmodic outbursts than of a continued and organised effort on the part of the workpeople to assert their rights. The mixture of races militates against the union of labour, and owing to the scarcity of hands employers are generally ready to make individual bargains with workmen. There was a strike at Passaic, New Jersey, during the author's visit. Instead of being a stubborn resistance, it merely lasted one day, and was distinguished by its intensity. The rioters paraded the streets, and attempted to prevent other workpeople from resuming work. This action resulted in disorder, which prevailed long enough for all the police and many civilians in the town to receive injury before the firemen restored order with hose-pipes. In this case the rioters were Italians. But the people are seeing the folly of such outbreaks, and more systematic methods, in opposition to the fruitless strike, are being introduced. The employers have strong combinations, as mentioned in Chapter VIII., and take every opportunity of engaging French Canadians or other non-union labour.

A comparison of wages paid in the dyeing industry of the three countries under review is very difficult to make, for the purchasing power of money has also to be considered. It was generally acknowledged that German wages were lower than English, and that the American rates were the highest of the three, both actually and relatively to the price of commodities. Calico printers, who had experience of industry in the three countries, gave the following figures for a calico printer: for Germany £2 : 5s., for England £3 and for America £6 per week. English calico printers living in New England stated that the conditions were much better in their new sphere than in the old country; wages were much higher, while necessaries did not cost much more than in England. Clothes, rents, luxuries and amusements were dearer, but for a quiet life the cost of living was similar to that of the old country. But in considering these opinions it must be remembered that an English calico printer is

offered high wages to cross the Atlantic, not because of any special quality of his work, but because of the information concerning English methods which he brings with him. Moreover, to simply compare workman and workman, as regards rate of wages, is of little use, unless we know how much employment is furnished at the different rates.

Wages in the German dyeing industry show an upward tendency. It is said that in Germany there are not the extremes of remuneration which one finds in this country, the German wages being more evenly divided. This latter development, however, is still more apparent in America, where a man is given any salary, no matter how big, in proportion to his value to his employers. In the United States, if an employer wishes to economise labour he does so at the expense of the lowest-paid hands; he does not begin by discharging those receiving the highest salaries, and for this reason the influx of unskilled labour due to immigration does not affect the higher salaried posts.

From time to time we are told that some European countries are beating us in some special line of industry because they have lower wages to pay. Germany's low wages and longer hours are said to be driving us out of many markets. This may be true to some extent, but it is also true that low rates of wages are hindering the progress of the German workman. He is forced into the rudiments of education, but class distinctions are so rigid in Germany that he finds it extremely difficult to rise to higher spheres of life. His wages are so low that his movements are restricted to narrow limits. On the other hand, in England one finds hundreds of "self-made men" who now occupy the highest positions, and a large proportion of the manufacturers engaged in the textile industries and their branches started as workmen. This class of men is practically unknown in Germany. The opportunities presented to children of poor parents in this country and in the United States make it possible for a child to forge ahead, and in this way the growth of a purely labouring class is impossible. Germany is regarded as the home of education, but one must have means before being

allowed to enter a university, and for this reason the larger part of the people are debarred from participation in the "splendid educational facilities" of the country.

A shorter working day has been introduced into some industries, particularly engineering, in this country; Germany is following us in this matter at a distance, and in some parts of the United States the people are awakening to the fact that short hours are in the long-run the most economical. A few of the large German works (for example, the colour-works) are introducing the eight-hours day and stopping at midday on Saturday. It is said that the United States have the eight-hours day in many industries, but this is not the case in the textile and dyeing industries.

CHAPTER X

EFFICIENCY IN THE INDUSTRY

Dyeing in Germany—Application of science to the art—The position in America—English workmen in America—Empiricism and science—Arrangement of the works—Using up of wastes—Aids to manufacture—Specialisation in the industry—Dye-works and machine shops—High specialisation in England—British pessimism.

As previously mentioned, Germany has some poor specimens of dye-houses, but the tendency is towards the extinction of such places, and larger and better works are arising. Thus from 1880 to 1890 the number of sheds in Germany weaving cotton decreased from 56,000 to 32,000, whereas the output increased enormously. The dyeing industry shows a similar tendency. Yet it cannot be said that their largest works compare favourably in any way with the huge bleaching, dyeing, and printing works of this country.

As to the state of the industry in Germany at the time of the author's visit, the reports from the industrial districts stated that the prices of dye-stuffs were falling, as were also the prices paid for dyeing. At Chemnitz the prices paid for dyeing silk, wool, cotton and linen showed a steady decline, and at the same period the business of dyeing both silk and cotton was by no means good in Crefeld. This was the case for both black and colour dyeing, while as regards turkey red the demand was becoming less and less, cheaper substitutes being sought.

We have heard much in the past about the application of chemistry to industry in Germany, but the author did not find that the Germans employ more scientific skill in their dye-works than we do. In fact, the wages paid

by dye-works are too small to attract the best skill; chemists prefer to enter the colour-works, which employ many chemists in all departments.

In dyeing, as in all scientific arts, countries approach more and more to the same state of efficiency. Secrets in dyeing and scouring existed more in the past, and if one country is much ahead in this industry, the circulation of technical periodicals all over the world, and the partial mobility of labour between countries, tends to equalise matters. This process of diffusion is, of course, slow, and the progressive countries gain certain advantages during the diffusion, but let us consider what the position would be if such a fictitious state of equality were arrived at. New discoveries would be made and inventions patented; success would then lie in the judicious use of these inventions. As regards our own industry, there is no doubt we derive some benefit from climate and hereditary skill, but these advantages will not avail us much if we fail to keep up to date and make judicious use of modern inventions.

In the dyeing industry the Americans do not shine. They treat larger lots than we do, and for that reason use some different methods; but in other respects they seem to be just following us at a distance and, by capturing as much of our talent as possible, making that distance as small as they can. Evidence before the Industrial Commission of the United States, 1900, showed that England was practically supplying the demand for trained workmen in the United States. Many Germans are employed in the calico-printing works, but the responsible positions are generally filled by Englishmen. In fact, the author got quite used to managers saying they used to work at certain Lancashire works. Englishmen are also employed as teachers in the textile schools. English machinery is largely used, but more and more American is being introduced as machine shops are being established.

America is exceedingly rich in raw materials. She has splendid supplies of coal, water power, iron ores near the surface and close to coal and limestone, great stores of copper, lead, zinc, corundum, quicksilver, asbestos, asphaltum, nickel, cobalt and kaoline, besides native wood

of great variety and excellently adopted for manufacture, building stones, slate and marble, besides cotton and wool. These resources must always be considered in accounting for America's position in any industry. The differential advantage produced by these resources is often accounted for in other ways, and in some cases the high quality of her labour has wrongly been given as a cause. For, as regards the textile industries, the labour is supplied by a collection of nationalities directed, as before stated, by British immigrants.

Empirical methods are prevalent in America as they are in this country. For instance, at one American works a man who had no scientific training was seen giving directions to the dyers and dispensing dye-stuffs in a most crude manner. The workmen brought pots and received dye-stuff, by the aid of a spoon, from one or more of a dozen cans. By long experience the man could tell how much he took on the spoon, but he admitted that weighing was the better method. The workmen passed to and fro between their machines and this man, bringing patterns and their pots to receive more dye-stuff, until the right shade was obtained. Weighing out the colour was stated to be too slow for them. The dye-stuff was invariably introduced to the bath in the solid state; either the importance of perfect solution was not recognised or the time taken for such an operation was held of more consequence.

But some of the American dye-works are conducted on scientific lines. At the Arnold Print Works, North Adams, Mass., success is largely attributed to the systematic and scientific working of the mill, while the Merrimack and Arlington Mills, two of the foremost mills in Massachusetts, are thoroughly up to date. The Arlington Works at Lawrence has a fine laboratory, and the chemist has an assistant who was educated at Lowell Textile School. They test all the materials which come into the works, and do washing and other tests of the dye-stuffs. They have a Bradford machine for determining the moisture in textiles. At the Merrimack Works all materials coming into the works are tested, no matter what their source, and the manager said the events of

the week previous to the author's visit had proved the wisdom of their plan. During the whole time they had received dye-stuffs from one of the largest German colour-works they had found no errors until this occasion, when a keg of rhodamine was found to be decidedly under strength. Previous testing had in this case saved a great amount of trouble.

At the present time one of the principal roads to success lies in using up wastes. Lord Masham said he maintained his house out of his sewer; and so many things are now recovered which formerly were allowed to pass into the sewers that manufacture has assumed quite a different aspect. This is undoubtedly the department where science can be of use, and where, in fact, it is certainly being of use. In America the treatment of waste products has as yet received little consideration, and wastefulness is an element of weakness in their manufacture. Owing to their huge resources the genius for petty economies has not been developed; the artisan is habitually indifferent to economy of material, and the employer is more concerned with economising labour. On the other hand, in Germany, the success of many of the business concerns has been due to attention to details and the practising of small economies.

In Germany and America one notices that industry receives every consideration. In Germany the State railways assist industry in all possible ways, and in the United States the authorities even allow trains to run down important streets rather than put the railway companies to the expense of laying special tracks. America seems to proclaim that railway development and industrial development must take place together. For instance, coal is found in Massachusetts, but being mixed with earth it is of little value, so that the coal for the factories in that important State has to be brought by rail from neighbouring States. One hears little in the United States about the development of waterways. The Erie Canal, so much used in the past for developing New York State, is only now used for lumber, salt, and coal; most of the large businesses use the railway entirely for transport. In Germany the principal use of canals is to connect the big rivers.

In connection with the aid afforded to manufacture in America, it was noticed that a manufacturer was not summoned if black smoke appeared from his chimney-stack, for at one time black smoke and even nitrous fumes were seen issuing from chimneys at Passaic, New Jersey. They are not so strict as we are in this respect, but then they have not the congestion of works that exists in this country. As mentioned in another part, grants of land at reduced rates are made at Lowell and other American cities.

As regards the state of specialisation in the dyeing industry of the three countries under review, it has been previously stated that the lack of specialisation in Germany is due to the fact that their primary textile industries and, consequently, their subsidiary dyeing industry are not so large as ours. Whole works do not devote themselves to special branches of industry, and usually a dye-works undertakes a large variety of operations. In America we find spinning, weaving, and dyeing performed by the same works, but in Germany this is seldom the arrangement; the subsidiary industry was founded as a separate industry at the same time as the textile industry itself was established, so that separate dyeing establishments resulted. In Germany one finds, however, that frequently textile machine shops are attached to dye-works. In these engineering departments the dyeing machines, which are used in the dye-works, are made and placed on the market. For example, Haubold's of Chemnitz, Gebauer's of Berlin, Kleinewefer's of Crefeld, and Bemberg's of Barmen, the large textile machine works in Germany, were originally and solely dye-works. In course of time machines were invented in these dye-works to facilitate the dyeing operations, and then these machines were made in quantity in a special branch of the works. In some cases general engineering works in the district were taken over, for the engineering branch of the business was found more profitable than the original occupation. Experience in the working of the machines resulted in the improvement of these machines; but the works mentioned now make not only their own improved and patented machinery, but machinery of all kinds.

Haubold's of Chemnitz is about the largest textile machine works in Germany, and a dye-works is run under the same direction. Gebauer's of Berlin have a large engineering works, which gradually developed from a dye-works. Seeing the importance of good machines, and knowing the requirements of the industry, they began to build machines. Later, they bought a works for making woollen machinery. They export machines to all parts, but few to England. Kleinewefer's of Crefeld have a large mercerising department, and a bleach- and dye-works alongside a machine shop, where silk-finishing and other machines are made. Bemberg's of Barmen, a large dyeing and finishing works for piece-goods, absorbed the engineering works of Mommer, and developed it along with the dyeing branch. They also held the Schreiner calendar patent. They make a hank-merceriser, calendars, presses, etc., and used to make a cop-dyeing machine until competition became too keen.

In America a few cases were seen where the dyeing and engineering industries were connected, but this was not general. Some works, from necessity, made some of their own special machines, but in few cases were these made for sale. The Cocheco Manufacturing Company of Dover, New Hampshire, however, make the "cell-dryer," and have put it on the market, but their principal business is the making, bleaching, dyeing, and printing of cotton goods, velvets, and velveteens.

In England, engineering of the kind mentioned is undertaken by specialised engineering works, and is seldom connected with dye-works. As our industry has developed, certain engineering works have specialised in the production of bleaching, printing, dyeing, and finishing machinery.

As previously mentioned, most of the dyeing in the United States is done in the same establishment as the spinning and weaving of the material, and even great developments have not resulted in the dyeing operations breaking away as a separate branch of industry. The tendency in America is rather in the other direction, that is, the works are increasing in size in the direction of self-sustenance. For instance, the Gera Mills at Passaic, New Jersey, have hitherto been known for their woven woollen

goods, but they have now begun to spin their own yarns in order to ensure a good supply. The different works specialise in the production of certain classes of goods, and they perform most of or all the operations required to turn the goods from the raw material into the finished products. In the same way the Germans make flannelettes as described in Chapter VI. This class of specialisation may be termed external specialisation. In the English textile and dyeing industries, however, another form of specialisation has developed, and this is of an internal nature. The dyeing industry is more specialised in England than in any other country, and to this development success in our various foreign markets is due. It has brought about great economies, so that other countries are striving to imitate our organisation. We have specialisation so developed that one district is known for fine spinning, another for weaving, while in dyeing, one works, or a combination of works, is noted for its turkey red, and another for its blacks. These separate branches of the industry have been developed to such a state of perfection that their productions cannot be equalled by any other country, and it is because of this high state of perfection that our export trade is so great. Specialisation has led to special training in particular branches of industry, and this mode of organisation is absolutely essential to British success. Similarly in the worsted industry we have the wool merchant, the comber, the spinner, the weaver, the piece merchant, the dyer, and the distributer. These operations are often carried on separately in this country, but in the United States mills are seen spinning, weaving, dyeing, finishing, and despatching their own woollen goods. In this country the dyeing is arranged for by the merchants, who send the goods to the dye-works which is known to have specialised in certain classes, whereas in the United States the dyeing is almost invariably done on the same premises as the weaving and other operations. In this country we have realised that in specialisation lies the strength of our industries, because a man concentrating his energies on one particular kind of work does that work as economically and as perfectly as possible. Moreover, specialisation of labour cheapens production, because a

habit is slowly formed, and we learn the shortest and best way of doing a thing only gradually.

It can be safely said that, as far as the dyeing industry is concerned, the exhortations sometimes addressed to us to reform our methods do not call for urgent consideration. We have been told from time to time that goods have gone from this country to Germany to be dyed and returned to us, and this fact has been often cited as evidence of the eminence of German dyeing. At the same time, however, no mention was made of the works in this country which have been continually approached by Germans and others to undertake work of the kind mentioned. In the case of one particular works, the author knows that German and Belgian goods were treated until the troubles of transportation made the works give up the business; that an Austrian firm had goods treated and was anxious to gain information as to the method of production; and that a Russian firm, after seeing some of the goods which had been treated at the works mentioned, offered payment for a knowledge of the method of treatment. And this was not a case of a special patented process, but only one example (and there are many others of the same nature) of a works having, by careful work and technical excellence, produced goods which no other establishment in the world could improve upon.

Again, the mere fact that the Germans issue a large amount of research work in the technical journals is regarded as a sign of great activity; it must be remembered, however, that much of this work is of little value. If, during research on industrial matters, anything of real value is found out it is not published but protected; the matter which filters through is generally of purely scientific interest only. Moreover, many of the methods which are published in technical treatises are those which have served a previous period, for new and important methods are not usually advertised by those who use them. Most of the German technical publications contain hardly any facts to add to industrial experience. Indeed, so much has been written on technical subjects that there is hardly any justification for new literature, unless it contains some real addition to our knowledge of the subject treated.

In English works a good deal of research work is carried out, although few of the results get into print. Those of a practical nature are used, and the rest of the material is generally filed for future reference. For instance, at the time of the introduction of mercerising, or it might be said the revival of that process, it is known that much research work was done on the subject at large works in this country. Some of the results were used in industry, and some were of scientific interest only. In later years, many of the same results were found by other experimenters and published for the first time. To those engaged in industrial research there is little gain to be obtained from the publication of results.

What the author wishes to point out is that, although the fact is not advertised by the publication of papers before learned societies, a large amount of research work takes place in our dye- and similar works, and as a result of this work processes are improved, economies are made, and modern methods used. Mr. Hooper, Secretary of Bradford Chamber of Commerce, said that "the very existence of the Yorkshire manufacturers and merchants depends on them keeping abreast with the times. No industry in the world has been subjected to so many changes or suffered so much from the vagaries of fashion as has the worsted industry; no other industry has shown more readiness to throw out obsolete machinery and instal new plant in order to meet the ever-changing requirements of the days, and so long as the Yorkshire manufacturers, dyers, and merchants maintain their present enterprise, inventiveness, and vigour, they have nothing to fear from foreign competition," and similarly Lancashire can hope for the same fate so long as she has her "energetic, self-reliant, and inventive people, and her excellent industrial and commercial organisation" (the late Elijah Helm). "The natural life seems as vigorous as ever, but the utmost energy and resource must be applied in every direction if we are to hold our own" (Sir R. Giffen).

CHAPTER XI

INSTRUCTION IN DYEING

The dyeing industry subject to change—British pessimism regarding education—Appointments for technical students—German technical schools—Education of the German workman — American schools — Suggested reforms.

The dyeing industry is probably more subject to change than any other branch of manufacture. In the first place, we have the changes brought about by reason of the large number of new dye-stuffs and of new classes of dye-stuffs which are continually being introduced; we have changes in the methods of dyeing with the old dye-stuffs; we have progress in manufacturing chemistry, leading to the cheapening of the production of some chemical, which thereby finds its way into the industry and causes a change of methods; and we have changes in the nature of the fibres themselves. When these facts are considered, along with the vagaries of fashion and the peculiar nature of the demand which the dyer has to meet, one concludes that only the most enterprising and progressive dyers can survive.

Perhaps there is no industry in which technical training plays so important a part, and no industry which in future will depend so much on technical skill as the dyeing industry. It is becoming systematic; it is settling into scientific order; the value of rule of thumb is decreasing; and looking ahead one can conceive of a time when dyeing will be performed by labourers under scientific direction. In the light of these facts it is interesting to record the steps which different countries are taking to supply technical instruction in this subject in order to ensure the survival

of their dyeing industries. If the books and papers which have been written on technical education are consulted, the definite conclusions that can be gathered are in reality few; the only substantial inference the author can draw from them is that the people of this country are very pessimistic.

If blue-books and the reports of commissions are consulted the reader is confused by conflicting statements. For instance, in the Eighth Annual Report of the Commission of Labour of the United States it is stated that England is ahead of America in that the English employer recognises the superiority of the technically educated apprentice in many mechanical operations, not as regards manual dexterity, but in the comprehension of general principles and in the power of reducing theoretical knowledge to tangible results. On the other hand, the Report of the Moseley Commission called attention to the deplorable apathy of English manufacturers towards technical education, and stated that the American manufacturer was ready "to pour out his money" to assist the progress of technical instruction. From another authority we hear that our shortcomings have received universal assent, but also practical neglect; a Royal Commission, it is said, has roused a feeling of consternation, but has been soon forgotten in that fatal optimism which is the normal state of the public mind. In the same direction a Departmental Committee of the Board of Education reported that in technical instruction Germany and other continental countries were much ahead of this country. And yet we found, a short time ago, a German professor deploring the backwardness of his country in certain branches of chemistry, and holding up to his countrymen the examples of England and Paris as pioneers in these branches of the science.

From these conflicting opinions it is difficult to arrive at a true conception of the position. The author thinks, however, that an entirely wrong impression exists as to the state of technical instruction in this country. Deputations going to Germany to study the German system of education do not get a clear view of the case. They start out with the idea that German institutions are far

better than ours, and, moreover, while there, only note those things which are actually brought to their notice. Further investigation, however, proves that a wrong impression has been created. Sir William White, in a speech before the Institute of Metals, called attention to the fact that certain Englishmen were belittling our industries and creating a bad impression in the eyes of the world. Truly the national pessimism extends to educational affairs. Whether a country is best urged on by the assumption of an optimistic or a pessimistic outlook is not to be argued here, but certain it is that, as regards educational affairs, most countries put forth a show of pessimism. The author, having had a university training, having been on the staff of a technical institute, having made a tour of the principal industrial centres of Germany and America, besides examining the technical schools in these countries, and having had some industrial experience, is prepared to attempt to turn a spirit of pessimism to one of optimism.

We have been told by one class of critic that English manufacturers are apathetic, and do not appreciate technical skill. But the fact that England holds such a commanding industrial position seems to point out that any fault does not lie with the manufacturers. When the right article is presented, our manufacturers are as ready to snap it up as those of any other country, although naturally few manufacturers are prepared, considering the mobility of labour, to train a man without an assured prospect of profit from the transaction. In educational matters it must be remembered that the direction of instruction is determined by the opportunities available for scientifically trained students in the commercial world. We have here the operation of supply and demand as in industry itself. Professor Ashley has pointed out that this is true of all branches of knowledge. For instance, he thinks that economics will never flourish as a university subject until it is made a subject for examination for some professional career, or connected with business life in some way, as is being done by the founding of the Faculties of Commerce at the universities. Considerable numbers of people might be drawn to universities and

technical schools by a passing interest, and mere habit might keep many of the students there after the interest has flagged; but certain it is that no study can flourish unless pursued with a professional object. Few students will be found to attend merely for the love of the different branches of knowledge.

So it is with technical education; as it becomes more and more a "bread and butter" requirement, so will it flourish in all communities. For instance, in Germany the polytechnics grant degrees, and on this account have undoubtedly grown in popularity. In Prussia no examinations take place unless certain specified rights, conferring privileges either for future study or for admittance to a certain career, result therefrom. It is a case of no rights, no examinations. An Englishman entering Germany for the first time is surprised to find that so many people understand English. The reason is that English is so necessary for their trade with England and America that there is a certain profit to be obtained from acquiring a knowledge of the language. Again, the exemption from a portion of military service of those who have a certain standard of education is of great benefit in urging many to study. Perhaps it is well for all to remember that examinations are not pleasant experiences, and a student has little inclination towards them if he sees nothing beyond. If in this country more public appointments were offered to university and technical school men possessing certain qualifications, then there would be a very great impetus to study.

But at the same time it must be admitted that the ladder by means of which a poor child can climb from the elementary school to the university is much more complete in this country than it is in Germany, since big scholarships are practically unknown in the latter country, and education divides the people into two rigid classes. This question of the pursuit of education for profit is well brought out in the quotation previously mentioned of a German professor deploring the fact that England and Paris were foremost in certain branches of chemistry. The branches, he specified, were inorganic and analytical chemistry. This is, no doubt, due to the large absorption

of the German chemical graduates by the colour-works of that country having inclined the study of chemistry to the organic side; the demand for organic chemists has influenced the direction of the study of the science. Indeed, it might be said that the excellence of these colour-works is the cause of much of the talk about superior German methods and systematic German chemical education; these concerns are continually held up to our notice. If Germany were suddenly to lose these works we would hear little more about the excellent business ability and technical education of our rivals.

It must also be remembered in considering all education that many individuals are incapable of seeing the gain to be obtained from submitting themselves to a course of instruction, and that many rate-payers are unable to see the necessity of the high education rate; such short-sighted individuals exist in all communities, and no doubt hinder the progress of thought and instruction. Although in Germany the supply of graduates is determined more or less by the demands of different occupations, it is found that there are many graduates who find difficulty in entering industry, and others who work for small salaries; this of course is the state of affairs in this country, and, in the nature of things, unavoidable. English chemists are found to wander abroad just as German chemists are found within our shores, for some of Germany's best chemists come from Zurich and England, while many more have benefited from a long stay with us.

Of the German schools which are devoted to teaching the practice of neighbouring industries, the one at München-Gladbach, which is the centre of the cotton industry of Rhineland, is among the newest. This school is somewhat like our smaller technical schools. The equipment and maintenance are provided by local manufacturers, aided by a small grant from the Prussian Government. It is under Government control. The building contains a boiler and engine-house, spinning, weaving, and dyeing departments, a chemical laboratory and lecture rooms. The spinning and weaving apparatus is mostly of a small size. The dye-house contains pots for sample dyeing, besides a few jiggers and small apparatus for dyeing.

Much of the machinery in the school was made in Lancashire, and it is worthy of note that many of the machines used in the cotton industry of the neighbourhood were supplied by us. The complete course of instruction at the school extends over two years, or four semestres, each of twenty-one weeks of forty-four hours. Students must be over sixteen, and possess a satisfactory general education. Special instruction is given in the production of cotton waste cloths, which are a speciality of the district. The school is designed to assist the local industry, and foreigners are only admitted at the discretion of the director; they are charged at the rate of £40 a year. Students from other parts of Germany pay £15 a year. At the time of the author's visit there were 32 day students, 8 of whom were foreigners, and 143 evening students. One noticed that the school was advertised in many of the works of the district.

The Crefeld Fachschule is one of the oldest schools of its kind, and since its establishment in 1896 has undoubtedly had much effect on the German textile industries, and at the same time gained a good reputation. This school is really a combination of a trades school and a school of chemistry, because it was recognised at its inception that a knowledge of pure chemistry is essential to the study of the dyeing and other branches of the textile industries. Lectures on physics, inorganic, organic, and physical chemistry, and patent legislation are given. Some of the chemical laboratories are used for research connected with the textile industry, and other rooms are fitted up for the usual chemical requirements; in a small experimental dye-house trials are made on a small scale. The large-scale apparatus includes hank-dyeing becks, raw cotton dyeing apparatus, centrifuges, silk-finishing machinery, and printing-machines, driven by hand and power. The director of the school receives a salary from the town of Crefeld, and he is allowed to do private work. At the Chemistry School of Mülhausen, instruction is given in pure and applied chemistry, but no large-scale apparatus is used. The school aims at giving special chemical instruction to those entering the dyeing industry.

Chemnitz, usually called the "Manchester of Saxony,"

because it is the centre of the cotton industry of that country, has a department of technological chemistry at the Staat-Lehranstalt. Here the teaching is of a theoretical kind; instruction is given in dyeing, but no large-scale apparatus has been installed. At the Charlottenburg Technical High School there are a large number of special chemical courses. The chemical department takes up a great portion of a large, handsome building. There are many research laboratories. Yet the author thinks that there is no justification for the exaggerated statements which have been made concerning this school. A mixture of an art and a technical school, it suffers by comparison with the Schools of Art and Technology in Manchester.

Karlsruhe has one of the finest of German technical high schools. Here pure and applied science is taught and degrees are granted. There is some dyeing in the district, and this industry is catered for at the school. Thus a research on the fading of colours under the light of the Cooper-Hewitt lamp was being carried out, at the time of the author's visit, by Professor F. Haber, and a new dyeing laboratory was projected.

In Austria one finds that instruction in dyeing is not well provided for, so that many Austrians visit other countries for their instruction. The Königliches Österreichisches Gewerbe Museum, Vienna, is a higher grade technical school which is supported by Austrian manufacturers and receives a Government grant. It is mainly used for the teaching of dyeing and printing from a theoretical standpoint. There are various testing departments. The only school in Austria devoted to the teaching of practical industrial methods is the Reichenberg Staats Gewerbeschule, which has been designed on the Crefeld pattern and contains a school of dyeing. Very low fees are charged and sometimes free tuition is given.

From the above short description of a few continental schools it must be evident to those who are familiar with the English schools of the same kind that at least, as far as equipment is concerned, England does not occupy a second place. It is true that many of the German technical high schools attract large numbers of students, but this is not the case with schools of the Crefeld type. The

Crefeld school itself had, in 1906, seventy students, which number, however, dropped to forty-five in the following year when the fees charged to foreigners were raised. The München-Gladbach school was for some time without any students at all. Sorau, a town in Brandenburg near the borders of Silesia and Saxony, and therefore quite near the dyeing industry of this part of Germany, built a school of the Crefeld type at a cost of a million marks and equipped it like a university, with a fine laboratory and machinery for bleaching, dyeing, printing, and finishing. At one time there were three instructors and six students, some of the students being foreigners. Further, we find that in Germany the schools are not very particular as to the quality of the student they admit; they make an effort to get as many as possible. It has been said that students from the high schools pass through the schools of the Crefeld type before entering industry; but the author found that such cases are exceptional, as these men have other outlets for their training. However, a student from a technical high school does sometimes find his way into a trade school, and then the authorities show their delight; they make no mention of men of inferior training that they accept. The technical high schools themselves are known to receive in their specialised technical chemical laboratories, students who have had little previous chemical training. Further, the author recalls the case of a Hungarian who had passed through one of the best schools of dyeing in Germany taking the full course, and who yet lacked even the most elementary knowledge of chemistry. He could not have known very much when he was accepted.

The volunteer departments of the German colour-works are now much patronised in place of the schools mentioned, but it must be remembered that the training obtained in these departments, although good, cannot become a substitute for attendance at technical schools: the experience is of a different nature, and can only be supplementary to technical instruction.

As regards the training and education of the work-people engaged in the German textile and allied industries, the situation, the author found, is very similar to the state

of affairs in this country. The employers are inducing the people to attend technical classes, and the law is applying as much force as it can in the same direction, yet few, other than manufacturers' sons, are taking much interest in the special technical schools described. The author found sons of English manufacturers in all parts of Germany picking up whatever knowledge they could. Thus one of these gentlemen was a chemist with one of the largest and most famous of Mülhausen dye-works, another was a kind of an apprentice in a München-Gladbach works where cotton blankets and other raised goods were manufactured, and many were being entertained by the colour manufacturers.

Turning to the United States, we find that schools of the class above described are springing up in most textile centres. The Fall River Textile School contains a small chemical laboratory and a dye-house containing vats for hank-dyeing, a machine for warp-dyeing, drying cylinders for warps, and other yarn-dyeing apparatus. The dye-house is designed to supply the weaving department, and contains no piece-dyeing machines. The instructor thought that the schools of this class ought merely to supply their own needs, but admitted that such a procedure did not give scope for instruction in piece-dyeing, printing, etc., and therefore did not encourage research in these branches of the industry. Some people in the town of Fall River consider the school a valuable institution, whereas others laugh at it and say a lad can learn as much in the works in a month as he can learn in the school in a year. These facts serve to show that technical education has had to fight against a good deal of prejudice in America as well as in England, and that the American is not so eager for technical education as some people in this country are apt to think.

Lowell, Massachusetts, has a fine-looking school, which was built very capacious to allow for future demands. The author was informed that the intention of the school was to train engineers to become managers. All students were expected to go through the whole course; there were a few special students, but these are not encouraged, as a general all-round training in the engineering, electrical,

chemical, and textile departments was aimed at. From the chemical department, which is fairly large, many chemists obtain positions in the local works. The department for woollen manufacture is particularly good; some Yorkshire but mainly Massachusetts machines are installed. For cotton-dyeing, the equipment consists of two jiggers, a Klauder-Weldon dyeing machine, drying cylinders, and a few other machines. Trials were mostly done on an experimental scale: thus some mercerising trials were being performed at the time of the author's visit. Both here and at Fall River the machinery was driven electrically. As regards the staff of the school, one noticed that one dyeing instructor hailed from Manchester, the head of the weaving department from Preston, while most of the other professors and instructors were educated at the Massachusetts Institute of Technology or at the other technological institutions in America. Some of the people of Lowell look upon the school with favour, others with amused contempt.

The textile school at New Bedford is very similar to the one at Lowell. The school at Philadelphia, the oldest of its kind in the United States, also requires little further description. The dye-house at the latter school contains the usual small-scale apparatus for dyeing, yarn-dyeing becks, a hydro-extractor, a small warp-dyeing machine, and a small printing-machine. Professor Walker of the Massachusetts Institute of Technology describes industrial chemistry as the introduction of the dollar into the chemical equation, so that in his applied chemistry department he tries to bring the student into touch with chemical industry. Thus one finds the student separating pure from crude salt, and barium nitrate from common salt by means of a consideration of the respective solubility curves of these salts, making Glauber's salt, and afterwards designing a plant for its manufacture. An attempt is made to get the student to think, and the element of cost is introduced during the instruction. The principles of bleaching and dyeing are taught, and the lectures are supplemented by practical work. Special lectures, for example, on calico printing are given from time to time by men actually engaged in the industry. Very little

instruction in dyeing is attempted. The director of applied chemistry said that the students from his charge never went to the textile schools, although he admitted that probably this was the best way for them to become of use. Yet he thought the chemist soon got into the work of the mill. Their idea was to train engineers, and the institute was really of the nature of a university. Their work overlapped that of Harvard University in the same city, but the University drew a different class of student. The number of their students had just been reduced because the standard of the entrance examination had been raised. At the primary schools, he thought, the scholars were taught obscure unnecessary subjects, and when they wish to enter for higher education they find that the entrance examination is too difficult: if they reduced the standard of this examination the duties of the students of the school were then too heavy. It is therefore evident that the same difficulty exists in America as has troubled our educatiomists for some considerable time.

At Columbia University, New York, a good feature of the chemical lectures is the inspection after the lecture of a large museum which contains many interesting objects connected with the subject which has been discussed. Visits to works are paid, and memoirs have to be written giving an account of the observations made. A little hank-dyeing is done, being part of a practical course connected with lectures on industrial chemistry given to third and fourth year students.

As may be gathered from the author's remarks, he is of the opinion that the dyeing schools of other countries do not compare with those at, say, Manchester, Bradford, Glasgow, and Leeds, and even with many others of lesser importance in these islands. Just as we lead in the production, preparation, dyeing, bleaching, printing and finishing of textiles, so also is this lead maintained as far as the technical instruction applied to these industries is concerned. Also it must be said that there is little difference between the positions of England, Germany, and America as regards the appreciation which manufacturers show of the training received at these institutions.

But although England is foremost in this class of

instruction, it must be patent to those knowing the conditions prevalent, that there are many respects in which our schools can be made more useful, and in this way gain more recognition from commercial men. The technical school should be the centre from which the manufacturers obtain the latest thoughts and progress in their industries. For instance, at the German colour-works, periodical conferences are held by the technical staffs, when any progress in colour manufacture is discussed and opinions on the products of rival works are given. In this way much valuable information is propagated. The publication of an abstract of these records would be exceedingly valuable to the dyeing world, and, although the issue of such a volume is improbable, one can conceive of such a publication being compiled by the staffs and students of our technical institutes. Manchester could report on innovations in the dyeing of cotton goods, and Bradford and Leeds on the treatment of wool. In this way much valuable information could be supplied to the industry, and such an action would meet with a response from the manufacturers. In connection with the recently formed Textile Institute there is the intention of supplying information to the trade, but surely much of this work ought to be performed by our textile schools. It is to be hoped, however, that this institute will be instrumental in acting as an intermediary between manufacture and the schools. Besides information concerning the properties of dye-stuffs, that concerning machinery might also be included in the report.

Again, our technical schools might advantageously adopt lectures on economics, *e.g.* banking, trade unionism, wages, organisation of industry and commerce, patent legislation, etc. Such lectures are given in some American institutions, and it is evident that instruction in the rudiments of these subjects, besides being interesting, would be extremely useful to those entering industry. Another point in which the writer thinks our schools are lacking is that concerning the prices of materials. The question of price should be held prominently before those evening students who are employed in works. We know that the uses of dye-stuffs are constantly being altered

because of cheaper substitutes being introduced, and a consideration of the prices of these substitutes along with their other advantages and disadvantages is essential. It is true that the price of an artificial dye-stuff is a vague quantity, varying from district to district and depending on competition and other factors, but an idea of their approximate cost would be very useful to those students already engaged in or about to enter the industry. One finds in a works that such questions as cost of power, cost of damaged goods, and depreciation are factors which largely determine profits, whereas in the school one never gave such things consideration. Of course, one soon becomes aware of these losses after entering the works, but a slight previous knowledge of works conditions would be extremely useful. In the case of a student entering a dye-works direct from a university without previously passing through a technical school, the position is extremely awkward and discouraging. The employer is anxious that his profit should be increased, and expects to be taught something. The chemist is in a maze: he is paralysed by unusual circumstances, and sometimes is not allowed time to recover from his embarrassment. This period of embarrassment and consequent inactivity would have been much shorter if the chemist had previously attended a technical school. Such institutions exist to place him in touch with industry. Chemists are thinkers, and as industry thrives in consequence of the thoughts of those engaged in it, it is necessary that it should draw the greatest thinkers.

As regards the statement that some British manufacturers have little trust in technical education, it must be remembered that a large number of our manufacturers were originally working men, who by virtue of their ability and their thrift worked themselves into their present positions.[1] These men do not understand what technical education really signifies, and therefore they cannot be expected to be very enthusiastic in its praise. But the danger arises when these manufacturers communicate

[1] See Prof. S. J. Chapman and F. J. Marquis, "The Recruiting of the Employing Classes from the Ranks of the Wage-Earners in the Cotton Industry," *Journal of the Royal Statistical Society*, vol. lxv. pp. 293-313.

their ideas to their sons, who in consequence are quite content with the education supplied by the local grammar school, and begin work under their father's care at the age of about fifteen years. It is true that this age is three or more years later than that at which the father made a start, but considering modern developments it is far too soon. What was sufficient for the father is by no means satisfactory for the son, if we are to train a new generation of scientific employers; and every manufacturer should give his sons a chance of a scientific education and some technical training. It will be found that four or five years spent in such training before entering the works will yield ample returns, and will be far more valuable than many years of industrial experience, for it will be found that problems arising in the works will be far more easily grappled with. Each year of experience in the works is apt to follow a law of diminishing returns, in the sense that during the first few years much is learned, while in subsequent years fresh knowledge is acquired at a much less rapid rate. It is for this reason that works experience can be advantageously deferred until a system of mind training has been undergone. But it is impossible to obtain this mind training after one has entered the works, that is, when one is older; the scientific training must be obtained while young, and must follow the ordinary school training.

CHAPTER XII

PROGRESS IN THE INDUSTRY DURING THE WAR PERIOD

Research Work—Bleaching—Dyeing—Re-dyeing—Mercerising—Printing—Finishing.

This branch of chemical industry has, like other branches, been affected by the war. The nature of the productions of many works has been entirely changed; the scarcity of certain chemicals has caused rigid economy in the employment of substitutes; and the interference with the dye-stuff supply has caused many difficulties. In fact, it is remarkable that the industry has been kept going in spite of all the difficulties.

Various new machines have been described, but, in the cases where full details have been given, there does not seem to have been any revolutionary change. Many of the inventions have been devised for special classes of work. As in most other industries, not engaged directly in the production of munitions of war, less research than usual has taken place; owing to the scarcity of labour and other troubles, the managers and technical men have required all their energies to keep the works going, and have found little time for experiment and the development of new processes. In the United States, however, a large amount of research in textile chemistry has been performed in recent years; in the countries which entered the war at an early stage the best brains were devoted to research connected with munitions, chemists being drawn from other industries.

This branch of applied chemistry has always attracted a number of chemists, perhaps more than most other branches of chemical industry. Whether these chemists have been of the first rank may be disputed in some

quarters, but certain it is that, in an unostentatious way, they have brought the industry to a high degree of scientific development. This development has also been assisted by the connection between the industry and the aniline dye-stuff industry, which is probably the most highly developed, in a scientific sense, of all industries. Yet it must be admitted that among managers and technical men employed in the industry there is usually a reticent feeling, a feeling which keeps them from discussing their successes and troubles with others outside the works. They always appear extremely anxious not to divulge anything of value, and in some cases are given strict injunctions by their superiors to that effect. "Secrets," however, leak out, and it is in the interests of the industry as a whole that discussions on scientific and technical points should take place.

It is gratifying to note that research in the industry has recently received official recognition and support. Committees have been formed by the Society of Dyers and Colourists, problems selected and grants in aid of research made; a number of problems have been considered by committees appointed by the Textile Institute and an important matter investigated; and the Society of Chemical Industry has received grants in aid of a research bearing on the technical development of the industry under review. Some progress has been made towards the establishment of a Cotton Research Association, to be devoted to research in connection with industries using the cotton fibre, and also to the education, particularly technical education, of those engaged in the industry. A Wool Research Association has been formed and a director appointed. Preliminary steps have been taken by the Silk Association to form a Silk Research Association, and already researches have been instituted. The Department of Scientific and Industrial Research has arranged with the Irish linen manufacturers for the establishment of a Research Association, and this body has also made a grant to the Textile Institute to assist in the cost of its journal, that is, to ensure the abstracting of matter of interest to textile workers.

Of the actual research performed a number of papers

have been published by the Society of Dyers and Colourists and grants in aid have been made. The list of proposed investigations is long, but difficulty has been experienced in getting suitable workers to carry out the researches. There seems to be a public awakening to the necessity for the application of research to industry. A large amount of work is awaiting execution, but it will be necessary to see that it is begun on a right basis if the industries are to obtain the full benefit. Moreover, it is well to remember that such work will depend for its success upon the progress of pure chemistry. Great efforts will require to be made to keep up this enthusiasm for research. It has already been pointed out that it is a great mistake to state that the German dyeing industry is in advance of ours. On the other hand, just as this country is foremost in textile manufacture, so also is this lead kept as regards the subsidiary industries of bleaching, dyeing, printing, and finishing. But this position should not suffice. Now that we have the lead, it behoves us to keep it, and research will be one means to that end.

Notable papers have recently appeared on the application of physics to textiles, and such papers, by inducing entirely new thoughts on these matters, are bound to lead to results of industrial importance, although it must be admitted that chemical investigations in this field apparently offer more chance of immediate returns. Leeds has of late become prominent in the application of physical science to the textile industry, and a number of industrial concerns, which have taken up research in textiles, have catered for the physical side. Few of the results obtained by these concerns, however, are likely to see print. This is a state of affairs unpleasant to contemplate. Certainly, results of scientific interest only could be published without any indication being given of how the results have been applied to industry. The publication of such results if it does nothing else makes a worker take more interest in scientific journals than he otherwise would.

A recent report[1] states that the offer of £150 a year

[1] Report of the Committee appointed by the Prime Minister to inquire into the position of natural science in the educational system of Great Britain, 1918, p. 73.

(as a pre-war standard) is not sufficient to entice good men into industry; but the present writer thinks that this initial remuneration, provided good prospects and additional rewards for successful results are offered, will be sufficient to attract students to this particular industry. The number of university graduates at present engaged in the industry is not large. In the past students have been warned not to take up this profession, because the outlook was poor and the chances of promotion small. But the industry requires these men if it is to make progress.

It is a remarkable fact that at different works similar results are achieved by different processes. Nobody seems to understand why the variety of processes are used, except that they have been found successful for years. One print works uses lime boiling for preparing the cloth, and another works, not many hundred yards away, uses caustic soda boiling. Because both methods give satisfactory results no further attention is paid to the matter; in industry results, not methods, are considered, provided economy is achieved. The processes mentioned are not yet fully understood, and it is in matters of this kind that research is required. It must not be thought, however, that a scientific chemist entering the industry can solve all the difficulties encountered. Textile chemistry is one of the most difficult branches of technical science, and long and painstaking research is required before any conclusions whatever can be arrived at.

The reason that textile chemistry is so difficult and depends so much on experience, is because the chemist is dealing with substances or mixtures of substances, the chemical constitutions of which are unknown. For instance raw vegetable fibres contain: (1) *cellulose*, on which a large amount of research has been performed, but no definite ideas gained as to its constitution; (2) *waxes*, the thorough investigation of which has only recently been commenced; (3) *proteins*, the chemistry of which is extremely complex, and the constitution undetermined; (4) *pectic matter*, about which little is known; (5) *colouring matters of undetermined constitution*; and (6) *mineral matter*.[1] This collection of substances of

[1] Barnes has recently shown that raw cotton gives as much as 1% of ash

unknown chemical constitution serves to indicate why the industry was founded on empiricism rather than on a scientific basis. The bleacher, dyer, and printer of textiles first aims at separating the non-cellulose constituents of the fibre from the cellulose: the bleacher's duty is to merely make this separation in the best and most economical way he can and with the least possible injury to the fibre. The methods used are the methods of accumulated experience, but chemical knowledge is being found of assistance.

At the present time a large amount of work is being done, all over the world, on the constituents of vegetable products, and this work will affect many industries. For instance, work on the constituents of textile fibres will have a marked influence on the textile industries and their subsidiary industries, for progress in textile manufacture will depend on our knowledge of the waxes, proteins, and pectins of plant fibres. Recent work on the action of chlorine on proteins is of interest, and serves to show the connection of an important industry with a branch of biological chemistry. Much work has already been done on the constituents of the cotton fibre, but the subject is a very large one. Perhaps the proposed Cotton Research Institute could not make a better start than the investigation of this subject. Further, this Institute in the first place ought to get the support of chemists and others engaged in the different branches of the industry. By discussions between chemists engaged in kindred industries mutual benefit would be derived and much duplication of labour avoided. Moreover, the work of the proposed Cotton Research Institute would be greatly assisted by the co-operation of the chemists mentioned, for these men, with a thorough knowledge of the chemical and other sides of their industries, would be of great use in organising this research work. Careful organisation would be of far more use than financial assistance from the Government. The sooner industry learns that research pays the better it will be for industry.

It is not out of place here to quote the following

on incineration, and the variable mineral content affects the properties of the fibre during dyeing and other operations (*Jour. Soc. Chem. Med.*, 1916, 1191).

remarks by B. Johnson and R. W. Hovey (*J. Soc. Chem. Ind.*, 1918, 136 T): "Cross and Bevan claim that the cellulose residues obtained from wood are not true celluloses of the same type as cotton cellulose, but that they are, in properties, true oxycelluloses, giving furfurol as a typical reaction. It must, however, be remembered that the furfurol reaction is by no means a characteristic reaction for oxycellulose, since, for instance, the typical oxycellulose obtained by treating cotton with bleaching powder solution does not give the reaction. Moreover, these cellulose residues do not show the most typical oxycellulose reaction, namely, the high reducing power (copper number)." Then M. Cunningham (*Chem. Soc. Trans.*, 1918, 113, 173-181) states that the whole question of the structure of the cellulose complex remains open, and Cross and Bevan (*ibid.* 182-187) throw doubt on the usually accepted furfuroid-pentosan relationship. The present writer also thinks that the celluloses should be regrouped, or at least some definite distinction should be drawn between the groups suitable for plant physiologists and those suitable for chemists. With the advance in our knowledge of the constituents of fibres, these fibres should now be classed according to the nature of the cellulose they yield on treatment. For instance, cotton and flax fibres contain similar non-cellulose constituents, although the proportions of these constituents are quite different in the two cases, and the celluloses, which are isolated from these fibres by the bleaching process, are chemically indistinguishable. These fibres ought, therefore, to be classed in the same chemical group, in spite of the fact that one is a seed hair and the other a bast fibre.[1] The use of such terms as pure, pecto- or adipo-celluloses are not required to distinguish these fibres. It is true that flax contains a small quantity of woody matter, but this is of little importance in the numerous operations through which the fibre is put, and the statement that flax cellulose is more easily hydrolysed than cotton cellulose is not supported by the observation of

[1] It has been shown (E. Heuser and A. Haug, *Z. angew. Chem.*, 1918, 31, 166, 172; *J.*, 1918, 650 A) that the cellulose separated from straw is indistinguishable from cotton cellulose.

the present writer that forty hours' boiling of scoured linen yarns, under pressure with alkalis, had no apparent weakening effect. If, after isolating the cellulose from a fibre, this cellulose is found to be different chemically from the cellulose of cotton, there is justification for putting it in another chemical group; but if it is not chemically different then it should be grouped with cotton. Grouping in this manner will tend to simplify matters and enable some order to be introduced into the present chaos of cellulose chemistry. In the case of another carbohydrate, viz. sugar, existing in plants, sucrose is given that designation, whether it be isolated from the sugar-cane, beet, or the maple tree. If, however, the sugar isolated is not identical with sucrose, it is put in another class. It is true that in the case of sugar, which is crystallisable, the grouping is simpler than in the case of different forms of cellulose, but the case of starch in the vegetable kingdom forms a better analogy. It is known that all forms of starch occurring in the vegetable kingdom are not precisely the same,[1] and all samples, like the celluloses, yield a small amount of ash on incineration, showing that they are complex substances; yet it must be admitted that collecting all the forms of starch together and calling them "starch" has simplified matters and assisted progress in operations in which starch takes part.

An important method of *bleaching* has been outlined by Levine (*J. Ind. Eng. Chem.*, 1916, 8, 298-302), who showed that the ether-soluble and nitrogenous constituents of cotton cloth can be removed by the action of certain bacteria in a nutrient solution containing certain inorganic salts; the cloth is merely immersed in the solution instead of being scoured with lime or caustic soda. Rôhm (Eng. Pat. 100224, 1916) treats raw cotton with a 0·1% solution of pancreatin at 20°-40° C. for some hours and then bleaches in the usual way. He later (*ibid.* 107191, 1916) protects the use of this solution for the cleansing of other articles than textiles, and Kwaisha (*ibid.* 106503, 1917) uses the proteolytic enzymes in the juice extracted from the bodies or cocoons of insects

[1] See A. R. Ling, *Annual Reports*, 1917, 406.

or silkworms in order to dissolve the sericin and loosen the fibres of silk. The use of enzymes in the bleaching of cotton is of interest; previously they had been used extensively to remove the size from cotton cloth before scouring, but in this new development the action of the enzyme is taken further, namely, to eliminate the fatty matter and the proteins from the fibre. The following questions, however, arise: (1) Can all the impurities be removed without resorting to ordinary scouring; (2) How does the cost of the enzyme and nutrient solutions compare with that of ordinary scouring solutions; and (3) If lime salts are present in the nutrient solution is it necessary to treat with acid after the action of the enzymes in order to eliminate the lime? It must not be forgotten that some enzymes attack cellulose, and unless this action be prevented the methods of cleansing mentioned may have an effect on the strength of the fibre, just as over-retting rots linen. It might be difficult to stop the action when the non-cellulose constituents of the fibre have been removed and the cellulose itself not attacked. Caustic soda boiling is found to have no deleterious action on cellulose, even on boiling with that solution for 40 hours under pressure. Moreover, weak caustic soda solution is an ideal cleansing agent for textiles, since it removes the waxes by saponification; it is the best hydrolysing agent for proteins, and it eliminates the pectic matter from the fibre. Perhaps the most important point in bleaching is to have a safe method of separating the cellulose. Only safe methods can survive. A method might be very scientific and economical, but if it results in an occasional lot of goods being "tendered," then the economy of the method disappears and the method cannot survive. In fact, methods which require careful scientific control in order to save tendering do not commend themselves to bleachers; methods which are not risky and can be entrusted to workmen not scientifically trained are preferred. Some time ago a method of bleaching cotton in one operation was described. The cotton was heated in the kier along with the scouring liquor, to which was added a certain quantity of a manganese salt, and air was passed through the goods while in the kier. The

idea was to oxidise the manganous salt by the air, the oxidised salt being reduced to its original state by oxidising the non-cellulose constituents of the fibre, and thus by a cycle of operations oxidising, and therefore bleaching, the cotton during the scouring operation. The method is ideal from the chemical standpoint. The writer has not heard if this process of bleaching has survived, but thinks the point mentioned above, namely, risk of tendering, would sooner or later cause its discontinuance.

The cause of the yellowing of bleached cotton on steaming and storing has lately been discussed. Levine (*Journ. Ind. Eng. Chem.*, 1916, 8, 298-302) confirms Hebden's (*Journ. Soc. Chem. Ind.*, 1914, 959) conclusion that the turning yellow is partly due to nitrogenous impurities; but he also finds that the ether-soluble impurities have some action. Freiberger (*Z. angew. Chem.*, 1916, 29, 397) states that cloth bleached with cold hypochlorite solution and then scoured did not keep so well on storing as the same cloth bleached in a warm alkaline and then a warm acid bleaching bath. The present writer (p. 103) found that any of the residual non-cellulose constituents of fibre had the effect of causing yellowing on storing, and that the only method of preventing this fault was by proper scouring before bleaching.

The present writer remembers a case of cotton piece goods being bleached by wetting out, saturating with bleaching powder solution, allowing to lie for some time, washing, scouring, and again washing. Goods bleached in this way were a fair white but would probably deteriorate on storage. They would certainly lose their whiteness on steaming, because the non-cellulose constituents of the cloth had merely been oxidised on the fibre and only partially removed. The fats and waxes are not destroyed by the hypochlorite, and on steaming they melt, thus causing the cloth to become darker in colour. Linen which had been given a three-quarter bleach was found to turn yellow on steaming, and the only way to prevent this change of colour was by bringing the bleach from a three-quarter to a full white (S. H. Higgins, *J. Soc. Dyers and Col.*, 1918, 34, 35). M. Freiberger (*Färber-Zeit.*, 1917, 28, 221, 235, 249) concludes that fats play no appreciable part in the

yellowing of goods during steaming, whereas "gums" cause yellowing during both dry heating and steaming. He states that the yellowing is due to β-oxycellulose. He emphasises the advantage of using warm sodium hypochlorite containing an excess of soda, since goods chemiced in the ordinary way show a much stronger discoloration. The author would require to state more fully what he means by the "gums" of cotton, and perhaps some further information might be desired concerning what he designates as β-oxycellulose.

As regards the tendering of bleaching vegetable yarns during storage, this fault has been shown by Higgins (*loc. cit.*) to be due to mineral acids which have not been completely washed out of the goods. It was shown that acid was very difficult to wash out of vegetable fibres. In the "creaming" of linen yarns there is a great danger of leaving acid in the yarns after the last washing process, and this acid might subsequently cause trouble. "Creaming" could be produced with less risk by using sodium hypochlorite and dispensing with the acid treatment altogether. Both as regards linen and cotton the writer was unable to agree with Cross, Bevan, and Briggs (*Journ. Soc. Chem. Ind.*, 1908, 260) that chloramines have important functions in bleaching operations. In fact, his experiments pointed to the conclusion that chloramines were of no interest to the bleacher. C. F. Cross replied by letter to the above-mentioned conclusions, and later J. F. Briggs took up the subject. Readers are referred to those letters and also to two by the present writer in the same journal (*J. Soc. Dyers and Col.*, 1918, 34, 76, 127, 176, 302). The present writer cannot be expected to give an impartial view of this controversy; but perhaps it is sufficient to say that his further work has shown that, after the scouring operations generally used in the bleaching of cotton and linen goods, these fibres contain practically no proteins. Alkalis are excellent solvents for proteins, and in the long boiling with alkalis in commercial bleaching operations the proteins are effectively removed. As a consequence, when these fibres enter the bleaching powder solution for the first time they contain practically no proteins. The possibility of forming chloramines is

therefore small, except of course from any proteins present in the water used in making up the hypochlorite baths. In this connection it is interesting to note the claim (C. Bennert, Ger. Pat. 304003; *J.*, 1918, 412 A) that proteins on hydrolysis with caustic alkalis yield products which, on treating with calcium or magnesium hydroxide, give substances useful as detergents and employed in dyeing and printing.

That scouring increases the strength and elasticity of cotton yarn has been confirmed (F. J. Jecusco, *J. Soc. Dyers and Col.*, **1917**, **33**, 34-38). If, however, the yarn was not properly scoured before treatment with the hypochlorite solution, there was an actual loss in strength. (See also Higgins, *J. Text. Ins.*, 1916, 38.) Seel and Sander (*Z. angew. Chem.*, 1916, **20**, 261) found no structural modification of cotton and linen, when viewed under the microscope, after treating with acids, alkalis, and oxidising agents. Wool, however, was affected by alkaline boiling, and soap instead of soda ash was recommended for this work.

Korselt (Ger. Pat. 287240, 1913) claims the use of hypochlorite solutions of gradually increasing, instead of decreasing, concentration. This method may produce a good white but certainly not a cheap one, considering the amount of strong hypochlorite which is retained by the cloth, and lost in the subsequent washing process. Briggs (*J. Soc. Chem. Ind.*, **1916**, 799) discusses the economy of hypochlorites in bleaching operations. The theory of the bleaching action of hypochlorites has been the subject of much controversy (Higgins, *ibid.*, 1913, 350, 359, 1064, 1153; 785, 1152; Taylor, *ibid.* 38), but it now seems to be established that their bleaching action is due to (1) the direct production of nascent oxygen by the hypochlorites, and (2) the production of nascent chlorine by the action of the hypochlorous acid present in solution on the chlorides also present. A number of observations bearing on this discussion have recently been made. It was found (C. Vallery, *Comptes Rend.*, 1916, 326) that very dilute solutions of hypochlorites decompose slowly, the velocity of decomposition being apparently represented by a portion of a rectangular hyperbola. It

had previously been shown (Higgins, *J. Chem. Soc.*, 1913, 1816) that the velocity of the bleaching action of such solutions could be represented in a similar manner. Ricci (*J. Soc. Chem. Ind.*, 1915, 714) states that the addition of chlorides, as a rule, has little effect on the stability of hypochlorites, although under some circumstances the addition has an appreciable effect on the stability and bleaching efficiency of the solutions (Higgins, *ibid.*, 1911, 185). A. Smith (*ibid.*, 1916, 185) supports previous work (Higgins, *loc. cit.*), showing that bleaching powder solution and sodium hypochlorite solution produced by the electrolysis of common salt solution give identical results in bleaching processes. The pink colour of hypochlorite solutions, sometimes noticed in laboratory experiments, but seldom nowadays in commercial liquors, has been attributed to the presence of ferrates; but further work has shown (Elledge, *J. Ind. Eng. Chem.*, 1916, 780) that it is due to permanganates, the manganese being derived from the bleaching powder. The present writer had noticed this pink colour in hypochlorite solutions in contact with manganese compounds, such as manganese dioxide (*J. Soc. Chem. Ind.*, 1913, 359). It is interesting to note the use of a mixture of bleaching powder and boric acid as a powerful antiseptic in surgery. This mixture had previously been used by chemists to prepare hypochlorous acid by distillation, and the present writer showed (*ibid.*, 1914, 1152), by adding boric acid to hypochlorite solutions, that an extremely active bleaching solution was produced.

The connection between bleaching solutions and antiseptics used in surgery has been pointed out (Higgins, *J. Soc. Dyers and Col.*, 1918, 33, 189), since all the hypochlorites which have been used in different forms during the war had previously been used as bleaching agents, thus strikingly showing the relation which exists between different branches of experimental science. Sodium hypochlorite produced by electrolysing a solution of common salt contains a large amount of unaltered salt; by adding boric acid to this solution an ideal antiseptic for surgical purposes would be produced.

Regarding the properties of hypochlorites the remarks

of R. L. Taylor (*J. Soc. Dyers and Col.*, 1917, **33**, 246; *J.*, 1918, 86 A) on the effect of exposure to light are of interest to bleachers. He had previously (*Chem. Soc. Trans.*, 1910, **97**, 2541) suggested exposing hypochlorite solutions to air before use in order to increase their bleaching efficiency, but Higgins (*Chem. Soc. Trans.*, 1911, **99**, 858) showed that by the time the hypochlorites had increased in bleaching efficiency they had lost a large proportion of their available chloride. Taylor now suggests that hypochlorites be preserved from the action of light. (See also White, *J. Soc. Chem. Ind.*, 1903, 132-134). T. Rettie, J. L. Smith, and J. Ritchie (*ibid.*, 1918, 311 T) suggest mixing freshly ignited quicklime with bleaching powder intended for export to hot countries, since in this way the loss of available chlorine is largely avoided and the formation of calcium chlorate inhibited. It is known that the addition of hydroxides to hypochlorites increases their stability, and, in the case of bleaching powder, this fact is also expected to hold, since the powder is hygroscopic; but it must also be remembered that the addition of hydroxides, while increasing the stability, also decreases the bleaching properties of hypochlorites, and also, from what has been stated above, the addition decreases the antiseptic properties. The lime which is added to the bleaching powder could not be separated when it has served its purpose, and the solution produced would have weaker bleaching and antiseptic properties because of the presence of the lime. In connection with hypochlorites used for bleaching, the claim (Deutsch Solvay-Werke Act.-Ges., Ger. Pat. 306193) for producing a dilute bleaching liquor by passing chlorine into sodium carbonate solution, then adding more sodium carbonate, is of interest, and also (K. P. McElroy, U.S. Pat. 1261572) the production of a high strength bleach by the reaction of steam and chlorine at about 100° C. to give hydrochloric acid and hypochlorous acid, the former being removed by condensation and the latter by absorption in caustic alkali.

A process which has recently been discussed and tried by some bleachers (J. E. Macilwaine, Eng. Pats. 29811 (1913) and 6317 (1914)) depends on the stimulating effect produced by adding sodium bicarbonate to bleaching powder solution. This effect has been described by

Higgins (*J. Soc. Dyers and Col.*, 1912, 28, 30) and used by H. D. Dakin in the preparation of antiseptics. In the particular process under consideration the cloth is impregnated with a solution of sodium bicarbonate and then run into the bleaching powder solution. The result is an active bleaching agent and the production of some calcium carbonate. This calcium carbonate has to be subsequently removed from the material by treatment with hydrochloric acid. Now suppose the cloth be treated with weak hydrochloric acid instead of bicarbonate when entering the bleaching powder solution. The result will be exactly the same, with the additional advantage that no insoluble calcium carbonate will be produced. This is an old method of procedure among bleachers, and, carefully performed, it is a far better method than the more recently proposed one.

A. Poulsen (Eng. Pat. 104048) bleaches loose fibres and other materials by boiling in a mixture of sodium carbonate and bicarbonate and then treating with sodium hypochlorite solution, while H. R. Anders (U.S. Pat. 1251614) uses lime for the boiling, and lime and a "substance carrying oxygen" for the bleaching.

The injurious effects of perborate soaps and similar peroxide bleaching agents is pointed out by P. Heermann (*Chem. Zeit.*, 1918, 42, 85). Metallic salts, *e.g.*, of copper and iron stimulate this destructive action, and these salts are often present in small quantities in stains on linen and cotton goods. (See also J. F. Briggs, *J. Soc. Chem. Ind.*, 1916, 80; S. H. Higgins, *J. Soc. Chem. Ind.*, 1911, 188.) In reply to attacks on his paper, Heermann (*Chem. Zeit.*, 1918, 42, 337, 342) supports his previous statement and contends that washing powders containing available oxygen will produce in some cases local destruction and perforation of fabrics. This fact had previously been proved (*J. Soc. Dyers and Col.*, 1912, 28, 30). Sodium silicate has been found to have an injurious action on cotton textiles in the presence of soft water; after washing with the silicate the goods are dull and chalky. The use of hard water caused the textile fabrics to have a higher strength after washing with soap, soda, etc. (A. Grün and J. Jungmann, *Z. angew. Chem.*, 1918, 31, *Ref.*, 146).

Degree of Bleaching of Cellulose

Many methods of determining what is called the degree of bleaching of cellulose fibres have been described from time to time, but this work has been of little interest to the practical bleacher; he contents himself with the usual strength tests, and only examines the material for the so-called oxy- and hydro-cellulose in cases of decided weakness of the fibre. The "copper value" of Schwalbe has been much discussed, but Freiberger (*Z. angew. Chem.*, 1917, 30, 121-122) states that certain precautions are necessary in applying this method. Further, he (*Färber-Zeit.*, 1915, 319; 1916, 26) attempts to classify the whites of bleached goods by observing the stains they produce with waste bowking liquors. Haller (*ibid.*, 1916, 6-8), however, points out that such a method of distinction is only applicable to goods bleached by the same system of bowking and bleaching. He ought to have further added that such a method of comparison could only possibly be of use when the same cloth was used in all the tests.

The behaviour of the waxes of textile fibres during the bleaching process is discussed by the writer (*J. Soc. Chem. Ind.*, 1914, 902), and the efficacy of the lime boil explained. (See also Higgins, *J. Text. Inst.*, 1916, 7.) Because of the difficulty of removing the natural waxes during bleaching, James Burt-Marshall, Ltd., and S. H. Higgins (Eng. Pat. 102892, 1916) extract the waxes by solvents before the bleaching process. Apparently with a similar intention Peckham (*Met. and Chem. Eng.*, 1916, 160) boils the cloth in a soap solution containing benzol, instead of scouring in the usual way, and, further, a solution containing potash soap, carbon disulphide, and olein has been suggested for removing grease from fabrics (S. Dyson and J. Dyson & Co., Ltd., Eng. Pat. 10311, 1913; *J.*, 1916, 887). A recent research on pectic matters (S. B. Schryvar and D. Haynes, *Biochem. J.*, 1916, 10, 539-547; *J.*, 1917, 577) is of interest to bleachers, and the removal of pectic matter from vegetable fibres by means of a hot aqueous solution of hydrochloric acid has been protected (B. Leech, Eng. Pat. 104202, 1916; *J.*, 1917, 451). In bleaching with an alkali peroxide a claim is made (Deutsche

Gold und Silber-Scheide Anstalt, Eng. Pat. 10916, 1915; *J.*, 1916, 925) for heating the bath immediately to 85° C. to produce a better white in a shorter time. To prevent the flocculation of calcium soaps in washing baths, the addition of a soluble colloid, *e.g.* glue, albumin, etc., is protected (Farbenfabri. vorm., F. Bayer und Co., Ger. Pat. 294028, 1914; *J.*, 1916, 1153).

In a paper on bleaching faults, J. F. Briggs (*J.*, 1916, 78) discusses most of the troubles with which bleachers have to contend, and a paper by Budde (*ibid.* 404) is of interest to those bleachers who are troubled with river pollution. On exposing bleached cotton to the action of the light of a Cooper-Hewitt lamp it was found to be "tendered" and apparently partially changed to "oxycellulose" (Dorée & Dyer, *J. Soc. Dyers and Col.*, 1917, 33, 17-19; *J.*, 1917, 211).

Owing to the war, acids have been costly and scarce. *Nitre cake* has been used in many cases in place of sulphuric acid and of hydrochloric acid for "souring" textiles. Except in certain cases, such as lime scouring, it has been found a good substitute; and even in the case mentioned it has been used, with advantage, after the goods have been well washed. Troubles of dissolving the cake and testing its acidity have been mentioned; special tanks have to be used, and the solution tested volumetrically (*Chem. Trade Journ.*, Jan. 8, 1916; *J.*, 1916, 109; J. R. Hannay, *J. Soc. Dyers and Col.*, 1916, 32, 65-66; *J.*, 1916, 48; P. Bean, *J.*, 1916, 1153. See also *J.*, 1917, 1216 A). S. J. Pentecost (*J. Soc. Chem. Ind.*, 1918, 169 R) calls attention to the presence of iron in some samples of nitre cake and the possibility of it causing trouble if used for bleaching.

The *tendering action of acids on cotton* has been investigated by M. Fort and F. Pickles (*J.*, 1916, 38), and discussed by J. F. Briggs (*ibid.* 78); cellulose does not form compounds with acids, and with mixtures of acids selective adsorption was only pronounced at high concentration (A. Leighton, *J. Phys. Chem.*, 1916, 20, 188-194; *J.*, 1916, 464). The tendering effect of acids on cotton was found (H. Wilkinson, *J. Soc. Dyers and Col.*, 1917, **33**, 148-151; *J.*, 1917, 707) to increase with

the length of time of contact and was reduced by washing with water or alkali. Zanker and Main (*Färber-Zeit.*, 1916, 27, 355; *J.*, 1917, 708) found that a mixture of Glauber's salt and acetic acid caused tendering of cotton, but that this was the best mixture to use in dye-baths for union goods.

Of interest to both bleachers and dyers has been the trouble experienced by many bleachers of cotton piece goods woven with coloured borders. Many new dye-stuffs have been used for dyeing the yarns for these coloured borders; in some cases "bleeding" into the white cloth resulted during the scouring process. The new dye-stuffs have been fairly fast to the usual tests, except the test mentioned, and when once the colours have "run" the bleacher finds it impossible to correct the fault. To prevent the bleeding of vat colours, padding the cloth with caustic soda solution, to which non-oxidisable salts have been added to prevent the solution of the colour, and allowing the goods to lie some time before the process of bleaching, has been protected (J. Graf, Ger. Pat. 288751, 1914).

The permanganate bleach for silk is stated (E. Ristenpart, *Färber-Zeit.*, 1918, 29, 37) to be preferable to that using peroxide, nitrite, or aqua regia, but care should be taken to avoid the presence of alkalis in the bath. A small amount of sulphuric acid is added. A better colour could not be obtained by repeated bleaching, for with many treatments a falling off in colour was noticed, the silk becoming brown and losing in weight and tensile strength.

A paper (R. K. Meade, *J. Ind. Eng. Chem.*, 1918, 10, 214) on the valuation of lime is of interest to bleachers.

Dyeing

The troubles to dyers caused by the interference with the supply of dye-stuffs has been discussed by Whittaker (*J. Soc. Chem. Ind.*, 1916, 783, 1201). Wood colours have been more used than formerly, although previous to the war they were used in large quantities by some yarn dyeing works ("The Dyeing Value of some Natural Indian

Dye-stuffs," Srivistava, *Agric. J.*, India, 1916, 53-64; "Cutch in Burma," *J. Soc. Chem. Ind.*, 1917, 208; "Dyeing Materials in the Philippines," *J. Roy. Soc. Arts*, 1917, 65, 553). A development of the production of natural indigo is reported (*J. Soc. Chem. Ind.*, 1918, 261 R), the result being a paste which has been found superior to synthetic indigo paste for heavy shades. It cannot be used for light shades, however, because of impurities. E. R. Watson (*J. Soc. Chem. Ind.*, 1918, 81 T) records a considerable loss of indican during the air-drying of the indigo leaf and suggests the immediate steeping of the leaves.

Of recent years there has been an inclination towards the production of fast dyes; fastness has received more consideration than hitherto. The use of vat dye-stuffs has extended, and there has been a marked activity in the production of new shades by the developing of azo-dye-stuffs on the fibre. Fast grey shades are produced on cotton by the oxidation on the fibre of di-β-naphthyl-4·4′-diaminodiphenylaminosulphuric acid (Farbenfabr. vorm., F. Bayer und Co., Ger. Pat. 296142, 1916); clear red to dark blue shades by impregnating the fibre with a sodium carbonate solution of arylides of 6-hydroxy-2-naphthol-3-carboxylic acid, then heating with a solution of an unsulphonated diazo compound (Farbenfabr. vorm., F. Bayer und Co., Ger. Pat. 294798, 1914); Turkey red shades by coupling an aromatic diazo compound with 2·3-hydroxynaphthoylaminothiazole (Farben. vorm., Meister, Lucius, und Brüning, Ger. Pat. 294780, 1914); fast black dyeings by coupling an arylide of 2·3-hydroxynaphthoic acid and a diazotised *asym*-dialkyl-*p*-diaminoazo compound (Chem. Fabr. Griesheim-Electron, Eng. Pat. 100804, 1916); and yellow to black shades by impregnating the cloth with a sodium carbonate solution of 2·3-hydroxynaphthoylaminonaphthosulphomic acids and then treating with unsulphonated diazo compounds (Farbenfabr. vorm., F. Bayer und Co., Ger. Pat. 296559, 1914). Further development of the use of formaldehyde for these fixations is shown in the production of fast red to blue shades by treating on the fibre with formaldehyde the dye-stuffs obtained by coupling tetrazotised diamines

with one molecule of an aminonaphthosulphonic acid and one molecule of an amino-substituted derivative of 2·5·7-aminonaphtholsulphonic acid containing a free amino group (Farbenfabr. vorm., F. Bayer und Co., Ger. Pat. 295072, 1914).

Other examples of dye-stuffs produced on the fibre are a brown shade by oxidising salts of aniline and its homologues mixed with an aromatic hydroxy compound containing no nitro, nitroso, or amino group, *e.g.* a phenol (J. F. Moseley and E. McCardell, Eng. Pat. 105349, 1916); an aniline black, said to be unaffected by sulphur dioxide, by the interaction, at a high temperature, of aniline, a diamine, and chloric acid, with or without another mineral acid containing oxygen, but without salts of copper, iron, manganese, vanadium, or chromium (Ehrenzweig, Ger. Pat. 291955, 1913); a deep black on wool, by treating with a solution of a mono- or poly-sulphonic acid and of a *p*-amino- or *p*-arylamino-aryl-β-naphthylamine, then chroming (Farbenfabr. vorm., F. Bayer und Co., Ger. Pat. 291021, 1914); fast khaki shades on wool by baths containing dihydroxy- or amino-hydroxy-naphthalene-sulphonic acids and copper salts (Farbenfabr. vorm., F. Bayer und Co., Ger. Pat. 291456, 1914); and khaki shades on animal or vegetable fibres by immersing them in bichromate solution, and then in a solution of a substance obtained by melting together four parts of a *m*-diamine with one part of a *p*-phenol (R. Vidal, Eng. Pat. 1024, 1916). The nature of the mordanting process is discussed by A. B. Clark (*J. Phys. Chem.*, 1917, 21, 776), a relation being shown to exist between the mordanting power of a metal and its position in the periodic table. The mordanting action of ferro- and ferricyanides is dealt with. Of the different examples of dyeing with mordants which have been described we have: the extract of the leaves of *Acer ginnala* gives black and grey shades on an iron mordant, khaki shades (*J. Chem. Ind.*, Tokyo, 1918, 21, 211) on a chrome mordant; and extract of wattle, which probably contains tannin in some form, produces shades of brown, fawn, grey, and drab on wool and cotton (*J. Roy. Soc. Arts*, Mar. 15, 1918). As mentioned previously a diligent search has been made

for natural colouring matters in order to substitute the dear and, in some cases, unprocurable artificial varieties. O. Diehl (*Färber-Zeit.*, 1917, 28, 233) describes the production of a fast black on an iron mordant by means of a mixture of alizarin and dinitroresorcinal, and F. C. Schmidt (Ger. Pats. 305275 and 305770), for the dyeing of logwood black on silk, protects methods of reducing the number of tin phosphate baths, and for obviating the usual treatment with tannic acid and with an aniline dye-stuff for the purpose of topping. Further, the substitution of sodium silicate for soap in the dyeing bath is claimed to give a higher loading. A shade similar to naphthylamine claret, and not having the objections of that dye-stuff, is said to be produced by dyeing with a mixture of alizarin and alizarin cyanin on an aluminium mordant (O. Diehl, *Färber-Zeit.*, 1917, 28, 212).

The use of titanium tannate and tanno-oxalate as a mordant has been described (Barnes, *J. Soc. Dyers and Col.*, 1916, 141). A number of shades on animal fibres are said to be produced by the action of metallic salts in the presence of nitrates and of an acid (E. and G. E. F. Lodge, *J. Soc. Chem. Ind.*, 1916, 409). In the dyeing of wool and silk with vat colours the addition to the bath of a small amount of alkali and of the hydroxide of a heavy metal has been protected (R. Wedekind, Ger. Pats. 287042 and 289314). For the dyeing of tussah silk Sen (*J. Soc. Dyers and Col.*, 1916, 243) recommends the methods used for dyeing wool, since this fibre resembles wool in its behaviour towards dye solutions. The interaction of certain dye-stuffs with copper during dyeing operations has been pointed out by J. R. Hannay (*J. Soc. Chem. Ind.*, 1916, 36), and the use of acetic acid in place of sulphuric acid for after-chroming has been recommended in order to prevent the partial destruction of the dye-stuff by oxidation (E. Grossmann, *Färber-Zeit.*, 1915, 7). O. Diehl (*ibid.*, 1916, 134) suggests the use of a slightly acid alizarin dye-bath and rapidly raising the temperature to complete the dyeing within a quarter of an hour. Sen (*ibid.*) has described a method of producing aniline black on wool.

In the production of aniline black, E. Bechtel (*Färber-*

Zeit., 1917, 28, 300) states that a mixture of hydrochloric acid and nitric acid may be used with advantage in place of the former acid, and sodium ferrocyanide may replace the potassium salt. Since ferrocyanide, aniline oil, and acids give a blue on vegetable fibres, there is a tendency to a bluish black. The Calico Printers Association and E. A. Fourneaux have protected a further method of producing aniline black (Eng. Pat. 115278), and a previously described process (*ibid.* 7345 (1908)) has been modified in that the use of aluminium chloride has been dispensed with and the proportion of *p*-phenylenediamine reduced. The presence of formic acid is necessary, but it may be used along with other acids (*ibid.* 113484). Further, the use of boric acid, either alone or with phosphoric acid, is protected (*ibid.* 116562) in order to prevent the loss of aniline during careless drying. In a further patent (*ibid.* 117987) various stipulations as to the amounts of the ingredients are made and the order in which the ingredients are used specified.

The addition of fat-splitting agents, such as Twitchell's reagent, to the dye-bath, in order to produce emulsification, has been protected (S. Aschkenasi, Ger. Pat. 303121). In hydrosulphite vats a homogeneous emulsion is produced on stirring.

Further work has been done by E. Lodge (*J. Soc. Chem. Ind.*, 1916, 41) on the application of sulphide dye-stuffs to animal fibres, sulphites and hydrosulphites being used for the reduction of the dye-stuff, and excess of alkali in the dye-bath avoided so as not to impair the strength of the fibre. Sen (*J. Soc. Dyers and Col.*, 1916, 32, 245-246) adds Turkey red oil to the bath to improve penetration, and describes methods of producing sulphide dye-stuffs on wool. The tendering of fabrics which have been dyed with sulphide dye-stuffs has been further investigated. The dye-stuffs are said gradually to liberate sulphur, which in the course of time becomes oxidised to sulphuric acid and thus causes the "tendering" of vegetable fibres. Various methods have been described and patented for preventing this defect of sulphide dye-stuffs. For instance, treatment of the dyed fabric with a bath of sodium acetate, thus leaving a small quantity

of this salt on the fibre, has been used; if sulphuric acid be afterwards developed, it acts on the acetate, liberating acetic acid, which does not injure the fibre. It is said (Zänker and Weyrick, *Färber-Zeit.*, 1915, **26**, 337-341) that fabrics dyed with black sulphide dye-stuffs, which will withstand heating to 140° C. for one hour without tendering, may be stored with safety. To prevent the "tendering" of the cotton of union goods dyed with sulphide dye-stuffs, an after-treatment of the fabrics with ammonium salts and chromates has been patented. This treatment also dyes the wool (Act. Ges. f. Anilinfabr., Ger. Pat. 293455, 1915).

The industry of *re-dyeing* cannot yet boast of an extensive literature, but the industry has assumed large proportions and high scientific development in some countries. The methods adopted are principally matters of equipment, special methods being used for special purposes, and there is little desire on the part of the users of these methods to make them public property. C. M. Whittaker (*J. Soc. Dyers and Col.*, 1916, **32**, 4-9) shows that exposure to light and air affects the affinity of flannel for dye-stuffs, and he suggests that the exposure results in the partial destruction of the amino groups of the wool. M. Fort (*ibid.* **32**, 109-111) states that the affinity of faded wool for various dye-stuffs is erratic, basic colours being taken up more readily after the exposure, but acid colours show a less decided affinity. He suggests methods of treating the wool to overcome this erratic affinity. He further found (*ibid.* **32**, 184-187) that whenever wool is browned by any agency, its affinity for dye-stuffs is altered. Silk is similarly affected, but in a less degree. The browning of the fibre is said to be connected with the development of degradation of the amino-acids of the wool. Some interesting remarks on re-dyeing are also made by Lake (*J. Phys. Chem.*, 1916, **20**, 761-808).

Slop padding is recommended in place of dyeing (G. Tagliani, *Färber-Zeit.*, 1915, **26**, 222-228) on grounds of economy; by using an oil in the dye-bath to assist the penetration, deep shades can be produced. Pack dyeing is discussed by F. Smith (*J. Soc. Dyers and Col.*, 1916, **32**, 128-135), the difficulties and methods of over-

coming "channelling" being dealt with. In foam dyeing, P. Sisley (*Bull. Soc. Chim.*, 1917, **21**, 155-157) shows that the concentration of colloids in a foam has a parallel in the concentration of colloids in the emulsified portion of an immiscible solvent, and the property of an emulsified liquid, *e.g.* a "broken" soap bath, of dissolving much more than the normal amount of liquid, is used to explain a number of dyeing processes involving the use of emulsions in fixing very slightly soluble dye-stuffs. The use of silk-worm chrysalides instead of soap to produce the foam in foam dyeing has been protected (G. Schmid, Eng. Pat. 100336, 1915). Papers on wood dyeing (Moll, *Z. angew. Chem.*, 1916, **29**, 405-409) and paper yarn dyeing (Kerterz, *Chem. Zeit.*, 1917, **41**, 43-44) have been published. The fastness of dye-stuffs has been treated, and standards fixed by P. Heermann (*Mitt. K. Materialprüf*, 1916, **34**, 153-156). For testing the fastness of dye-stuffs to light, A. Ganswindt (*Färber-Zeit.*, 1917, **53**, 49) uses a lamp enclosed in marble plates, which have been soaked, at a high temperature and pressure, in a non-volatile hydrocarbon; although highly transparent, the marble absorbs the dark heat rays, and therefore provides a light eminently suitable for using in testing the fastness of colours to light. A method of determining alizarin in dyed fabrics is described by Leigh (*J. Soc. Dyers and Col.*, 1916, **32**, 205-213).

A number of papers bearing on the theory of dyeing have appeared; it has been shown (Rohland, *Kolloid Zeits.*, 1915, **16**, 16-18) that the adsorption of dye-stuffs by colloidal clay increases with the colloidal nature of the dye-stuffs, and that (Pfeiffer & Wittka, *Chem. Zeit.*, 1916, **40**, 358) aminoacids and polypeptides (and hence probably proteins such as wool and silk) combine with neutral salts to form molecular compounds during the dyeing process. Further, Fort has shown (*J. Soc. Dyers and Col.*, 1916, **32**, 33-40) that sulphuric acid employed in the dye-bath combines with the wool base to form an additive salt which reacts by double decomposition with the salts of the colour acid of the dye-stuff. Knecht and Hibbert (*ibid.* **32**, 226-230), in experimenting on the adsorption of dye-stuffs by charcoal and silica, found

that animal charcoal, in these experiments, could not be regarded as a form of the element carbon, since the nitrogen contents of the charcoal had a marked influence on its affinity for dye-stuffs. This is an important observation, for one of the strongest supports of the mechanical theory of dyeing was the different behaviour of two forms of the same element, namely, graphite and animal charcoal, towards dye-stuff solutions; it was shown (J. Hübner, *Chem. Soc. Trans.*, 1907, 91, 1057) that the former behaved like cotton and the latter like wool in baths containing different dye-stuffs. The relation between electrical endosmose and the adsorption theory of contact electrification has been shown (T. R. Briggs, H. L. Pierson, and H. S. Bennett, *Amer. Electro. Chem. Soc.*, 1917, May); the phenomena encountered in dyeing are said to be in accordance with the ionic adsorption theory. No further work has been done on the adsorption of dye-stuffs and of moisture by textile fibres since it was shown (Higgins, *J. Soc. Chem. Ind.*, 1909, 188) that an analogy exists between the adsorption by textile fibres of moisture from the air (*i.e.* a vapour from a gaseous medium) and of dye-stuffs from solution (*i.e.* solids from a liquid medium). The question as to whether the absorption of moisture by vegetable fibres is a chemical or physical phenomenon is by no means settled, but the writer thinks that much enlightenment would result from further investigation of the two absorptions mentioned.

The theory of dyeing has been discussed by members of the Society of Dyers and Colourists and by P. E. King (British Association, *First Report on Colloid Chemistry and its Industrial Applications*, 1917). Besides the old chemical and mechanical theories of dyeing there are many explanations of dyeing phenomena which lie between these theories; some observations, such as the dyeing of vegetable fibres by substantive cotton dye-stuffs, are not regarded by any group of chemists as being due to chemical reactions. It must be admitted that in this realm of speculation, progress will largely depend in the advance of our knowledge of physical chemistry, on the development of the theories of ionisation, and of the

colloidal state. W. Harrison (*J. Soc. Chem. Ind.*, 1919, 111 R) states that the electrical theory of dyeing provided explanations where the chemical theory failed, although it was not opposed to the latter theory. T. R. Briggs, H. S. Bennett, and H. L. Pierson (*J. Phys. Chem.*, 1918, 22, 256) describe an electrical endosmometer, and discuss their observations on solutions of acid and basic dye-stuffs with reference to the adsorption theory of dyeing. In studying the distribution of basic dye-stuffs between isobutyl alcohol and water it has been found (H. R. Kruyt and J. E. M. van der Made, *Proc. k. Akad. Weterisch. Amsterdam*, 1918, 20, 636) that the presence of sodium salts of different acids affords a series in which the amines are arranged in the same order as in the lyotropic series. In the case of the adsorption of dye-stuffs by blood charcoal this lyotropic influence was also noticed, and the authors suggest that this line of inquiry should be productive of elucidation of the dyeing process. Two papers on the dyeing process have been published by R. Haller. In one (*Kolloid Zeit.*, 1918, 22, 49) he points out that jellies formed by certain substantive cotton dye-stuffs with water are similar to soap jellies, and the formation of the jellies seems to be dependent on the presence of small quantities of an electrolyte in the dye-stuffs. The action of these electrolytes cannot be explained, but it is evident that they play an important part in the technical application of these dye-stuffs. In a second paper (*ibid.* 22, 113) he states that the adsorption compounds of dye-stuffs, with a crystalline substance such as barium sulphate and with a colloidal substance such as cotton, behave as mechanical mixtures rather than as chemical compounds, the difference in the compounds being entirely due to the varied physical characteristics of the adsorbents. The mixture hypothesis is supported by the behaviour with solvents, the nature of the absorption spectra of the solutions, and the determination of the melting-points. In the case of mordants, chemical compounds are probably formed with dye-stuffs, these compounds subsequently forming adsorption compounds with the fibre during the process of dyeing.

An exchange of opinions has taken place between

W. Harrison and M. Fort over the behaviour of wool towards acids and solutions in dye-stuffs. Harrison (*J. Soc. Dyers and Col.*, 1918, 34, 57) found wool which had been treated with acid gave up all this acid to boiling water on repeated extraction, and that the extracted wool had no greater affinity for dye-stuffs than the untreated wool. He concluded that the dyeing of wool with acid dye-stuffs is a colloidal chemical phenomenon. Fort (*ibid.* 34, 124) replied that on treating wool with acid, the acid cannot be entirely washed out of the wool. He points to the practical value of the theory of the acid-wool compound as opposed to theories based on little understood electrical phenomena, and states that Harrison's results do not explain the decomposition of neutral salts by wool. The behaviour of wool in dyeing operations, he states, is due to its protein contents. It has often been pointed out that wool holds acid very tenaciously, and the present writer remembers washing a sample, which had been heated with acid, for a long period with distilled water. On that occasion it was found that the wool still retained a slight amount of acid. Recently much advance has been made in determining the nature of the constituents of textile fibres, and also much headway has to be recorded as regards our knowledge of proteins. Theories of dyeing must make room for this knowledge and assimilate the fact that proteins, which are contained in raw vegetable fibres to a small extent and in animal fibres to a larger extent, have sometimes basic and sometimes acid properties, according to the nature of the substances presented to them. Fort's remark that belief in the chemical theory of dyeing is helpful in practical matters cannot altogether be regarded as evidence. The present writer has always been as convinced of the mechanical theory, and in dyeing operations he always has upheld this theory and indeed used it as a guide. It is possible that with those using vegetable fibres the mechanical theory of dyeing is taken for granted, while in other centres, namely, woollen districts, the chemical theory is supported. Of this contention we have a notable example in the late Walter Crum.

As regards the fastness of dye-stuffs to light, the efficacy of a layer of oil or wax in excluding the unfavourable influence of moisture and thus increasing the fastness has been mentioned (K. Gebhard, *J. Soc. Dyers and Col.*, 1918, 34, 74). The fading of dye-stuffs may be prevented by the dislocation of the original equilibrium between the oxygen in solution and the ions of the water (the perhydroxyl ions), by preventing or impeding the reactions between the dye-stuff and the perhydroxyl ions and by the transformation of the dye-stuff peroxide into more stable compounds. A. Robson (*J. Soc. Dyers and Col.*, 1918, 34, 185) describes a method of standardising the fastness of dye-stuffs to light by the measurement of the quantity of actinic light required to produce a visible change in the tone or depth of the test sample. This is assisted by noting the number of consecutively exposed standard strips of a quickly fading colour, which are completely bleached under the same conditions. Objections to the method are admitted.

The number of dyeing machines which have been described is few, and apparently no distinctive advance has been made. A machine for dyeing yarn on the pack system (J. Annieg, Eng. Pat. 113575) arranges that the flow of dye-stuff solution takes place by force from the side walls of the machine and along the threads to be dyed placed horizontally in the machine and approximately in the direction of the flow.

That the different processes of dyeing have an effect on the combustibility of the finished material has been pointed out by G. E. Holden (*J. Soc. Dyers and Col.*, 1918, 34, 7-9). The ultimate destination and the burning test should receive consideration before selecting processes of dyeing. W. Thomson (*ibid.*) called attention to the fact that black dyed velveteens, containing iron, burned until only the ash remained, whereas other velveteens, dyed with different dye-stuffs but containing no appreciable amount of iron, gradually became extinguished.

Mercerising

A number of processes have recently been patented depending on the action of sulphuric acid of various strengths on cotton. Mercer, in his original specification, mentioned the use of sulphuric acid of 105° Tw., but subsequent experience in mercerising showed caustic soda to be the best reagent to produce the swelling and lustring of the fibre; moreover, it could be used without risk of damaging the material. Heberlein und Co. (Eng. Pat. 100483, 1916) produce novel effects on cotton fabrics by (1) alternately treating them with alkali lye of 15° B. and sulphuric acid of over 48° B., and (2) submitting the cotton fabric (previously mercerised) to the action, in places, of sulphuric acid of strength greater than 50·5° B., then washing and again mercerising (*J. Soc. Chem. Ind.*, 1917, 133). Another method, devised for producing transparent effects on cotton, is by treatment with sulphuric acid of less than 50·5° B., cooled to at least 4° C., and subsequently mercerising with caustic soda (Akt. Ges. Cilander, Eng. Pat. 103432, 1916). Heberlein und Co. (Eng. Pat. 108671) produce transparent effects on cotton goods by treating with caustic alkali of a density above 20° B. at temperatures below 0° C. The transparency is increased by subjecting the treated fabric to sulphuric acid of about 50·5° B. In the U.S. Patent (U.S. Pat. 1265082) the conditions mentioned are treatment with caustic alkali solution of at least 15° B., washing, and then treating with sulphuric acid of at least 50·5° B., both treatments being carried out at a temperature below 0° C.

The strength and elongation of mercerised yarns has been shown (T. Nakata, *J. Chem. Ind.*, Tokyo, 1917, 20, 1224; *J.*, 1918, 203 A) to depend on the thorough removal of the caustic soda after mercerising, on the amount of stretching to which the yarns are subjected in the mercerising machine, and on the moisture contained in the yarn before mercerisation.

No particular advance in the practice of mercerising can be recorded; in recent years attention has been devoted to the economy of the soda lye, and few changes

in the process itself have taken place. Mercerised goods, hitherto imported from enemy countries in large quantities, have now been produced in this country, and there seems little possibility of this home trade being lost. The tests to distinguish mercerised from ordinary cotton described by J. Huebner (p. 29) have been used with success in industry. Of interest to mercerisers is a method of recovering lime from spent caustic mud by filtering and calcining in a kiln (J. H. Payne, *J. Ind. Eng. Chem.*, 1915, 1056).

A. Leighton (*J. Phys. Chem.*, 1916, **20**, 32-50) has investigated the absorption of caustic soda by cellulose and, after criticising previous work, supports Huebner and Teltscher's (*J. Soc. Chem. Ind.*, 1909, 641) conclusion that there is no experimental evidence of the formation of any chemical compound of cellulose with sodium hydroxide. Various explanations have been given of the fact that mercerised fibres absorb more moisture from the air and more dye-stuff from solution than ordinary cotton fibres. R. Haller (*Kolloid Zeits.*, 1917, **20**, 127-145) states that the outer membrane of the cotton fibre consists of two structural elements, thus supporting Nägeli's micellary theory of the structure of vegetable membranes. The absorption of dyes and mordants by the penetration of those substances into the micellary interstices is dependent on the power of dispersion of the particles, and in the case of mercerised fibres, the micellae being more widely separated than in ordinary cotton, particles of larger size are admitted, thus accounting for the increased shade of dyeing produced.

As regards the theory of the mercerising action, W. Harrison (*Proc. Roy. Soc.*, 1918, A, **94**, 460) regards the shrinkage which takes place during mercerisation as being due to the balancing of the internal stresses of the fibres. He studied this action by using polarised light. Regarding the twists in the natural fibres, W. L. Balls (*The Development and Properties of Raw Cotton*, A. & C. Black, Ltd., London) points out that when the cotton plant is thirty-three days old it is easy to distinguish simple pits in the cell-walls of the fibres; these pits are common in many kinds of vegetable cell-wall and are

not in any way peculiar to cotton. Given such pits, the fibre must twist when it dries unless the wall has been thickened so much as to obliterate the central cavity almost entirely. Twisting may be left or right; the direction appears to be accidental. Further, he states that lustre is probably almost synonymous with twist; if all the hairs in a sample are well and evenly twisted, there will be an infinite number of convex surfaces, each reflecting a spot of light. In addition to this there is diffraction of light which can be seen by holding a well-twisted fibre against a dull background with a good north light well overhead. It seems more than probable that the causes of lustre changes lie behind the cuticle, because the cuticle is one of the last plant tissues to be affected by ill-treatment. To the present writer these remarks offer a strong support to the theory of Huebner and Pope (*J. Soc. Chem. Ind.*, 1914, 23, 404) as to the increase of lustre by mercerisation. Discussing the strength of yarns, Balls states that the strength, within limits, follows the amount of twist which is put into it, even the variations in the strength of yarn after mercerising being accounted for in this way.

The causticising of soda liquors has been fully discussed (M. L. Griffin, W. H. Howell, jun., and G. K. Spence, *Met. and Chem. Eng.*, 1917, 17, 599), many systems being described, and the saving in space produced by using filter presses emphasised.

Printing

The use of resorcinol to dissolve the lakes formed by tannin with basic colours has been suggested (Wosnessensky, *J. Soc. Dyers and Col.*, 1916, 32, 278-280); it can also be used for discharging these colours on a tannin ground. For the fixation of acid dye-stuffs on cotton, the use of the condensation products of aromatic amines and aldehydes has been protected (Know Mill Printing Co., Ltd., and F. W. Weeks, Eng. Pat. 102291). Two methods of producing white and red impressions on indigo-dyed goods has been described (G. Tagliani and Brosio, *Färber-Zeit.*, 1915, 26, 1-3), and prints of great fastness

to light are said to be produced by 1·4·5·8-tetrahydroxy-anthraquinone, using an aluminium mordant (Farbenfabr. vorm., F. Bayer und Co., Ger. Pat. 290975, 1914). The use of a reducing agent, a citrate, and "Blandola" (pure vegetable gelatin) for producing white or coloured reserves in printing with chrome colours has been patented (Durand Huguenin et Cie., Ger. Pat. 293359, 1915), as has also the use of phenol-formaldehyde condensation products for the fixation of metallic powders, pigments or dye-stuffs (Bakelite, G. m. b. H., Eng. Pat. 7284, 1916). E. Dzieyk (Ger. Pat. 290598, 1914) describes the use of Manila copal and paraffin to produce by grinding with dye-stuffs, dust-free, dry, transfer printing colours for embroidery work; the colours are fixed by spraying with alcohol. The production of novel effects in union fabrics by printing with substances which are capable of destroying one of the fibres present, then subjecting to a high temperature, has been protected (Zeidler, Ger. Pat. 293400, 1914).

The fixation of dye-stuffs during printing is brought about (C. Jäger, G. m. b. H., and R. W. Carl, Eng. Pat. 116109) by mixing with the dye-stuff a substance containing a protein and a substance which yields formaldehyde at the temperature of the printing machine. The formaldehyde reacts with the protein. The Calico Printers Association and F. Ashton (Eng. Pat. 117715) produce chromium mordants on vegetable fibres by immersing in a chromium salt solution and in caustic soda of strength not less than 20° Tw.

Finishing

This branch of the industry has been little affected by the application of science, but in some branches there is evidence of the success of this application. The Austrians have made a success of the finishing of heavy mercerised goods, and they have done this by the special preparation of the cotton for this purpose; the spinning, weaving, and subsequent finishing have all been specially adapted to produce the best mercerised article, just as this special adaptation has been carried out in Germany to produce heavy "raised" cotton goods. Few papers on finishing have appeared. P. Bean (*J. Text. Inst.*,

)15, 4, 223-232) has discussed a number of modifications : starch, and the analysis of sizes and finishes has been eated by Lamb and Harvey (*J. Soc. Dyers and Col.*,)17, 33, 19-20). Glue in place of starch has been sug- ɜsted for sizing, and starch and diastafor in place of ɜxtrin (E. Ruf., *Z. ges. Textil Ind.*, 1915, 18, 140).

The weighting of silk can be carried as high as 180%, ɔcording to Anmann (*Färber-Zeit.*, 1915, 26, 301-303), ıe degree of weighting being influenced by the physical haracteristics of the fibre. Heermann (*M. A. K. Material- rüf*, 1915, 33, 446-453) states that no definite additive ompound between the stannic chloride and the silk in veighted silk has been proved. He favours an electro- ytic theory, the attraction of the silk being governed y the state of electrolytic dissociation of the stannic hloride.

As regards cotton sizing, R. H. Pickard (*J. Soc. Chem. nd.*, 1918, 26 R) points out the empiricism of the process ınd the need for research. The investigation of this)rocess, however, is difficult because of such intangible haracteristics as the feel and appearance of cloth, which lo not allow of definite measurement. The same remarks ıpply to the finishing of dyed and bleached goods; ɜxperience is still the only factor in this branch of the ndustry. A method of finishing fabrics by exposing them n the open width to a variety of operations, including brushing, exposure to steam, calendaring, and stretching has been protected (Columbia Conditioning Co., U.S. Pat. 1270153). W. Harrison (*Proc. Roy. Soc.*, 1918, A, 94, 460) states that double refraction in textile fibres is due to internal stresses which may be increased by com- pressing the fibres. When the pressure is released, the fibres do not revert to their original form nor lose their increased double refractive powers until immersed in cold water; but cold water is not capable of influencing the natural internal stresses of the fibres. At high tem- peratures, water renders fibres plastic, and deformation produced by compression does not cause internal stresses. These observations are of interest in studying the calendar- ing and other finishing process. Such investigations may succeed in infusing some scientific information into the

empiricism of finishing. M. Fort (*J. Soc. Dyers and Col.*, 1918, 34, 9) records a case of mechanical powdering of the cotton fibre during the beetling process. A deposit resembling lumps of starch was obtained which was easily crushed to a smooth powder. The product still had the properties of cellulose.

In the weighting of silk, the weighting liquors, phosphate and stannic chloride, are alternately forced through the fabric rolled on a metal drum. The drum is then removed to a drying machine and the fabric is dried by centrifugal action. The treatment is repeated until the desired loading is obtained (F. J. B. Knäbiehler and A. Fankhauser, U.S. Pat. 1259526).

For the treatment of waste liquors from textile and dyeworks, the use of chlorides or sulphates of alkaline earths and then highly plastic clay has been protected (C. Gunkel, Ger. Pat. 304040).

CHAPTER XIII

COLOUR PRODUCTION [1]

The German works—Past, present and future—Combination and its possible effects—Our position—Possible remedies—Protection—Patent legislation—Organisation of the industry in Germany.

THE German colour-works are perhaps the most perfectly developed and scientifically managed organisations in the world.

The English coal-tar colour industry has received much attention from many publicists, but our industry has principally been reviewed historically in order to elucidate our past faults. The past has been considered too much, whereas a peep into the future is of more importance. Everybody now knows the story of how Germany has deprived us of our aniline colour industry, how we send coal-tar to her and receive back finished products for which we pay dearly, and how difficult it is for us to compete with her in this industry now that her works are so large and so carefully organised. But the possibilities of development have not been argued.

The industry originated in England, and further progressed in this country as the result of a series of chemical triumphs. Hofmann was in England experimenting, but later, unfortunately for our industry, he returned to Germany. From this time we made little progress, because we had not the chemists to undertake the research work necessary for the industry. In Germany the conditions were different, for, thanks to Liebig, an army of young chemists developed the industry in that

[1] This chapter has been left practically as it appeared in the first edition.

country, relying on foreign raw materials. England was better prepared for the development of this industry because of our cheap acid, alkali, fuel, intermediate products, and raw materials, and because our gas industry, which supplied the crude coal-tar from which the dye-stuffs were made, was more developed than that of any other country. Our position differed from that of Germany in that the latter country had the research chemists; we had not, or, rather, those that we had were either unwilling to take up this branch of work or were not encouraged to do so. At a later time the acid and alkali industries developed in Germany, and had to thank the aniline colour industry for this rapid change. The coal-tar industry developed much more slowly than their dye-stuff industry, and as a consequence Germany had to rely on foreign raw materials for the manufacture of dye-stuffs. The imports of raw materials for this purpose, however, became less and less, until at the present time the Germans practically supply all their own needs.

The success of their coal-tar colour industry is attributed by the Germans to their research chemists, but it should rather be stated that success was due to the encouragement of these chemists. At first the German chemists came to England for capital to work out their ideas, and many of them were engaged in the Manchester district; but they afterwards found that they could get the assistance they required at home, where such men as Bayer and Cassella, who were not themselves chemists, supplied the business and financial element. In short, research was encouraged in Germany but not in this country. Brilliant chemists left England to achieve great success in the German research laboratories. Professor O. N. Witt said progress in Germany had been due to the development of the people during the last hundred years, to research, to the combination of science and technique, and to the fortunate organisation of the chemical industry. Further, the Chemical Society and Industrial Chemical Society had had a big influence in fostering the industry through their journals.

That is the past, and the fact that these German colour-works now export about £10,000,000 worth of

coal-tar colours and similar products, nearly a fifth of which are sent to this country, gives some idea of the present position of the industry in Germany.

In considering the loss of our industry we must not consider it a pure loss, but remember the people who would have been engaged in that industry are now following other pursuits. The actual loss is the difference in the income obtained in the two cases by the employment of the same labour and capital in different directions. Certain countries are better adapted than others for the working of certain industries, and the arrangement of industries between countries changes with time. Sometimes, indeed, the existence of an industry in a country is somewhat fortuitously determined. Thus the English cotton industry originally came to us from the Netherlands by the emigration of skilled workers from that country. This industry assumed a tremendous scale in this country, and in spite of the after developments of the industry in almost every other country of the world, we have maintained an unrivalled position in this branch of manufacture. It is seen that a small event decided the establishment of the industry in this country, and similarly we might say that a small event, namely, the encouragement of a few research chemists, decided the establishment of the aniline colour industry in Germany. But when we consider our position as regards the dye-stuff industry, we cannot for a moment maintain that our capital and labour is more economically directed at the present time than it would be if we were employed on a large scale in this industry; for we know that the German coal-tar dye-stuff industry is a very profitable one; we know that we have great need of dye-stuffs; and we know that in the past the Germans have used our raw materials, and from the profits obtained by the chemical transformation of these materials have founded their industry on a sound basis.

The existence of this huge industry in Germany has also another effect. A short time ago a German professor deplored that Germany was not so progressive in the inorganic and analytical branches of chemistry as in organic chemistry. He said France and England were

taking the lead in these branches. The fact is, that the colour-works in Germany are absorbing so many of the German chemical students, that as a consequence the organic side of chemistry is flourishing. In this instance we have the demand for labour influencing the direction of study, and the large colour-works have in this way been very influential in maintaining the standard of teaching of chemistry in Germany. Moreover, it is the author's firm belief that it is because of the development and the organisation of these colour-works that we hear so much of the scientific German, who is busy applying science to industry. The colour industry is a great asset to Germany.

Turning to the industry itself, we find in process of manufacture substances which were unknown a few years ago, and in some cases even a few months ago. With intellectual advancement man's tastes have become more and more complex, and in his taste for new colours lies the success of the industry under review. But, like most other innovations, artificial dye-stuffs were not at first enthusiastically received. After making some headway, there was a reaction in favour of the old methods of dyeing and printing, but finally the utility of the new products was proved, and the industry progressed at a great rate.

The separate firms have become very large and, moreover, there is a tendency towards combined working. Thus, there is a working understanding between the firms of F. Bayer of Elberfeld and Leverkusen, the Berlin Actien-Gesellschaft für Anilinfabrikation, and the Badische Anilin und Soda Fabrik. In fact, the Bayer and Badische firms already work their business together in the United States. Further, the two Frankfort works of L. Cassella of Mainkur, and Meister, Lucius & Brüning of Hoechst, are acting in a similar manner, so that two large concerns promise to arise and to drive small competitors out of the dye-stuff market. That the small works are troublesome to the larger ones from time to time is shown by the following experience. A Swiss and a German firm were competing to supply a certain product, and the latter firm wished to come to an agreement as to the sharing of the profits, so as to avoid ruinous competition. The terms offered to the smaller Swiss firm, however, were not considered sufficient,

and war began. The larger works probably won in the long-run, and also probably injured its competitors, for in this way the powerful combinations mentioned may get the entire market to themselves. Besides the combinations mentioned, it is also known that there are certain agreements between different firms of the two combinations. In fact, the whole German colour industry is organised so as to prevent ruinous competition, and intermediate products which are not required by one works are sold to others where they are required. At the time of the author's visit there was an agreement between two colour firms to keep up the price of sulphur blacks in München-Gladbach: the indigo convention between the Badische and Hoechst firms is also well known. Numerous other conventions exist in the colour industry, such as that between the British Alizarin Company and the foreign producers of that substance. Competition forces the prices of colours down enormously, and agreements like those mentioned above are welcome retreats for both parties. But if such overtures can take place between units of rival organisations, it is conceivable that a time will arrive when the German colour industry will be organised under one set of directors, or at any rate such a connection will exist between the combinations mentioned that a monopoly will be created. Such a powerful combination could undersell our small works, drive them from existence, and finally get the dyeing industry of this country entirely in its grasp. They might put the price up in America and at home, and, while keeping the price in this country very low, yet obtain a profit. Supply price may be placed below cost of production in order to gain a market. The price of an artificial colour is so uncertain a quantity that this "dumping" could easily be brought about if rigid combination existed in Germany. A German firm, which exploited the direct cotton colours, originally sold one of these colours at 6s. per lb., but nowadays the price obtained is only 6d. and the firm does not wish to supply it. This example gives one an idea of the profit obtained in the sales of these products, and shows that prices might in many cases be much reduced, in order to achieve some purpose, and yet a profit made.

In Germany there is a tendency for businesses to come

to a common agreement. A kind of executive government of the heads of the various businesses is formed, and they agree upon a joint government ruling output and sales. They also fix the home price, and sometimes the "kartel," for such is the arrangement termed, pays a bounty on exports if there is any loss occasioned by being compelled to sell at a low price abroad. The loss is thus distributed among the whole of the businesses and does not cripple single concerns. The kartels differ from the present form of most of the American trusts in that they have not advanced to a unified management of production ; they are combinations for maintaining prices and, more or less, for the joint marketing of the produce by a number of concerns, which retain their own independence as producers. It must be said that combination often checks unhealthy competition and provides up-to-date conditions, and, if well worked and organised, a trust may be the very best of economic factors. Large-scale operations are, within limits, the most profitable and often result in better conditions for the workmen than in small works. In the United States the tendency is rather for the combination to become an individual business, a trust being formed by the sale of businesses to a company ; one huge business entirely absorbs the individual businesses. In Germany and in this country businesses show an inclination to get larger, but not to the same extent as in the United States. Moreover, in England the degree of trade combination is considerably less than in Germany and America, where this artificial state is aided by another artificial restriction, namely, the high tariff. The German kartels have notoriously sought to relieve the home market in time of depression by selling abroad below the domestic price.

Considering these facts, we come to understand our position as regards dye-stuffs. The dye-works of this country are so dependent on German dye-stuffs that it is not pleasant to contemplate what would happen if these supplies were stopped or interfered with. Any rupture in the trade between the two countries would lead to most serious difficulties, and our trade in dyed goods with other markets might be permanently and irretrievably injured.

Prices are becoming so much cut that increases in cost of production, however slight, must be felt.

As regards the kartels existing in the colour industry, it must be remembered that although competition within the kartels is restricted, this arrangement sometimes gives a chance to the smaller works of obtaining business. Thus, in one instance, one of the big firms had had a contract for years and quoted for a renewal of the contract, having some idea of the price which the firms in the rival kartel could supply at, and knowing that the firms in its own kartel would not compete. The small outside producers were not, however, considered, with the result that the firm lost to one of the smaller firms a big contract. The small works are making a big fight, and are employing the best talent they can get, sometimes attracting men from the larger works. The larger organisations have technical men in all the industrial centres of the world, and these men meet from time to time at the German headquarters to discuss business matters. On one occasion one of the smaller colour firms sent men to stay at the same hotel as the other technical men mentioned, with the result that they heard all the doings of the conference discussed at table. This information they made use of, and now the rule has been made that the men must not discuss business matters off the premises. It is thus seen that the small firms are still full of life, and by their enterprise are preventing the consummation of a rigid monopoly in this industry.

Further combination will cause many dye-stuffs to be taken off the market, for the separate firms produce many of the same colours, although sometimes under different names. An individual concern, working in strict competition with all other concerns, had to supply as many colours as possible in order to satisfy their customers and in order in many cases to obtain fresh accounts. But with combination the tendency will be towards specialised production, and a series of the best colours will be produced. This arrangement will also assist the dyer in his selection.

Our position in the colour industry has often been pointed out and remedies suggested. Although large-scale production has many advantages, it is seen that

small works flourish in Germany and in Switzerland, and there is no reason why they should not do so in this country. Germany is a long way behind us in the textile industries, but she is gradually decreasing our lead. Although the larger the scale of production the more profitable production usually is, yet countries cannot be conceived as having large and unconquerable starts over other countries. One English firm is making headway on the Continent and is receiving respect from German chemists. Their dye-stuffs have received very favourable reports, while recent booklets issued from the works show no lack of enterprise. It must be remembered that one of the principal reasons why the German colour industry flourishes to-day is because of the application of keen business ability in the management.

Protection would have little effect in keeping out the German dye-stuffs, and the cost of production of our dyed goods would only thereby be raised. The German firms might erect works in this country, as they have done in France, Russia, and in other countries, and this arrangement might benefit employment a little, but the national benefit would only be small. Our present producers of coal-tar colours would not benefit materially, because they would not be allowed to work the German patents, so that our dyers would still have to import their colours or fall behind in the production of the latest shades; in order to obtain the novelties from time to time sent out by the colour firms, our dyers would have to pay the ordinary price, together with the tariff which had been placed on these products. In Germany many raw materials are admitted duty free, as coal, lime, tar, pitch, turpentine, wool and hair, raw copper, lead, tin, zinc, hides and skins, and some chemicals; but not alkali, alum, bleaching powder, or salt. In any case, considering the circumstances mentioned above, aniline colours are raw materials to our cotton, woollen, and other industries. In the United States salt and most chemicals are taxed; but white arsenic, sulphur, crude nitrates, petroleum, tar, turpentine, and wax are admitted free of duty. America, like Germany, recognises that the raw materials of industry should not be taxed.

Another solution of the problem of aiding our almost defunct coal-tar colour industry, and one which deserves more attention, is that relating to our patent laws. These laws were intended to introduce new industries to the country, but by granting patents to foreigners we have prevented the development of many processes at home, and foreigners coming to this country have been granted monopolies which their own country refused them. It is generally conceded that making the inventor work his patent in the country where it is taken out—a method adopted by all European countries except our own—is the best direction for reform. The Germans worked our patents in their own country at the beginning of the coal-tar industry, and were so successful that they firmly established themselves financially. "English brains created the colour industry, English enterprise developed it, and English legislative folly has been the principal cause of its decline" (Ivan Levenstein, *Nature*, 1903). In the United States legislation has not been passed to force foreign inventors to work their patents in that country, but the high tariff has a somewhat similar effect. The question of patents, however, has to be carefully studied in order to ensure against evasion of the compulsory working clauses, for there is the possibility of an inventor working his patent on a very small scale, thus satisfying the clauses mentioned, but at the same time preserving his monopoly. Legislation regarding patents is of great importance, and some German technical schools have lecture courses on this subject.

Turning to particular examples of patented products, we find the German firms, immediately they discover a new colour, patenting it all over the world. Of course the chemists turn out many colours which, after consideration, are not put on the market, but those which are considered worthy of manufacture are well guarded and patented. One German firm employs for this purpose a man who holds doctor's degrees both in chemistry and in law. The German firms are continually taking out new patents, and if this rate of progress continues one can conceive of a time when the chemical part of the colour industry will be so far developed that little further progress can be

made. Then after a term of years all patents will have run out, and other manufacturers will be able to make the previously protected products. The Germans recognise the possibility of this development and, while continually bringing out new products, they make their profits out of them while they are new; the prices obtained for real novelties are high, but after a time they sink considerably. Moreover, the German colour-works, recognising the probability of other manufacturers producing their colours when their patent rights run out, are taking great care that their specifications should be designed to give protection, but at the same time little information as regards the working of the patents. In this matter they have shown great cleverness. Further, they are spending large sums on research work, because they recognise that only in this way can they flourish.

England has set examples to the world and has been imitated on all hands in many business matters, and has so created many competitors. As regards our position in the colour industry, it is evident that we can only achieve success by following the methods by means of which the Germans have succeeded.

Of the German colour-works the Badische Anilin und Soda Fabrik was founded in 1865, at which time the

fastness of the colours. They were not far behind when sulphur colours were introduced, and they produced the first green. The Bayer firm has advanced very rapidly, until now it is one of the most important. It is significant in this connection to note that they have the most patents, 1000 German and 1200 foreign, and at the time of the author's visit employed the most chemists.

The business side of the German colour-works is highly developed. They make all they possibly can for themselves. Passing through the departments in which the different handbooks are made, one is struck with the enormous trouble and expense of such productions. Many of these are quite artistically produced, and contain scores of patterns, all of which have to be fixed by hand. These patterns are issued for cotton, wool, half-wool, silk, half-silk, leather, soap tints, straw, buttons, wood plait for hats, wood stains for picture frames, etc., and the intending customer is thus presented with reliable and trustworthy samples of the dyed article besides elaborate instructions how to perform the dyeing. Also some of the handbooks give drawings of the latest machinery in use, and although this is of German manufacture, yet one gets an idea of what is being done in Germany. The books are issued in about a dozen languages, including Japanese. The importance of good pattern-books is manifest in many industries, and the Germans seem to have developed this branch of business to a high state. Hundreds of clerks are seen at work in the different factories, and from the scores employed in the English departments, occupied solely with the trade with England, one gets an idea of the magnitude of that trade.

In all cases the works are built where good transport facilities exist. Thus, most of them are situated on or near the Rhine, while the Berlin Company's works is on the Spree and thus in connection with Hamburg. All have ample railway communication, and in some cases private lines. As one stands on the banks of the Rhine and watches the many barges floating down the stream, one is reminded that this river is a mighty factor in German commerce. Here we have no large initial capital expenditure as in the case of our canals, but a natural

means of the cheapest transport; the products of the industries of Rhineland are thus taken down to the sea and enabled to compete where otherwise they would not have a chance. The importance of cheap transport is becoming greater and greater, and it has often been said that England, both as regards external and internal communication, is the home of transport anomaly. The way that some foreign goods are carried to parts of England at cheaper rates than our own produce, and the way that English ships carry goods from other countries a greater distance at a cheaper rate than they carry ours, thus defeating us in some foreign markets, has often been mentioned and deplored. However, it must be remembered that the enormous development of Rhineland as an industrial district had resulted largely from the presence of the Rhine and its use as a means of transport. Moreover, this fact should not be lost sight of in comparing the relative growth of England and Germany industrially. It is said that the Thames has done more for England than all its canals and perhaps even its railroads.

An interesting part of the colour-works is the manufacture of the dye-stuffs themselves. Of course different dye-stuffs require different methods of production. In one case a building about 70 feet high was used. This had big tanks arranged at different heights and containing different chemical preparations. The liquids from these tanks were run at certain periods into a vat, and the dye-stuff was produced by interaction. It settled out of solution on standing, and by filtering through presses came out like clay. The liquid filtered off is further utilised, and the clay-like mass is put into barrels and taken to the drying ovens. These ovens are heated by fires below the ground, and the dye-stuff is wheeled into the ovens at the ground level. Different temperatures are used for drying, according to the nature of the dye-stuff being dried, and the ovens are specially constructed to admit of regulation. The dye-stuff is dug out of the barrels by means of spades and placed on trays, for transference to the ovens. Dye-stuffs of all kinds are scattered about the ground, giving it a peculiar appearance on a wet day. Moreover, one sees workmen of all colours emerging from their working

quarters and making for the baths. Each labourer engaged in dirty work has to have a bath before leaving the works, and they require it.

A large amount of ice is used in the colour-works for cooling purposes during the manufacture of diazo colours, and this ice is made on the premises. At one works, long rectangular iron boxes were seen standing vertically in brine, which is maintained at a low temperature. These boxes are filled with water and agitated by a lever arrangement; when the water is frozen the iron boxes are tilted and the ice removed. Some works make as much as 200 tons of ice daily.

At Bayer's Leverkusen Works, on the Rhine, near Cologne, the water-supply is obtained from a deep well. The pumping-engines are capable of raising 60,000 cubic metres of water per day, and this is 10,000 cubic metres in excess of the daily consumption of the city of Cologne. Of course this amount of water is not used at present, but the whole of this works is designed for future needs. There is plenty of room for expansion.

The author paid a visit to a works at Nüremberg where colours of a different class were made. Nüremberg has many industries, and prominent among these are the production of mirrors and of lithographic supplies. At the works mentioned fine metallic colours were produced by heating powdered metal with aniline colours. Different alloys of copper and zinc are used. Aluminium is used alone for this purpose, but not along with the other two metals, as a slight amount of aluminium produces brittleness and spoils the whole melt. Aluminium had at the time of the author's visit risen greatly in price, owing to an understanding between European and American producers. The copper used is the purest metal obtainable, and is usually produced electrolytically; it is beaten out with hammers and washed with sulphuric and tartaric acids. The colours are used for wall-papers, print cloths, and in lithography. The trade with Great Britain is large.

In recent years marked advances have been made by English employers as regards the housing of their employees, and similarly in Germany much has been done in this direction. This is particularly the case at the large

German colour-works. Thus, at Hoechst there is quite a town of artisan dwellings, each of which has a garden. Also there is a store, where provisions are sold by the firm at little more than cost price, a school, a continuation school for workmen, a library, an assembly hall, a huge dining-hall, and other conveniences. Hoechst itself is a very dirty place, but by the aid of a policeman and the increasing intensity of the fumes proceeding from one of the works' chimneys, the author was able to find his way through the unpleasant portions of the town to the much better district, where the colour firm's work-people were housed. The neat dwellings in this quarter are in big contrast with the squalid shanties of the town itself. But it must be mentioned that it is only the more respectable work-people who live in the houses mentioned ; the lowest classes find other places of abode. At all the works good kitchens provide excellent, cheap dinners. Besides the above conveniences some works have also savings-banks, hospitals, long-service premiums, pension funds, workmen's relief funds, musical societies, clubs, etc. A director of one concern sends workmen's wives and little ones to summer resorts, and pays for milk for the children at certain times of the year. The German firms are making huge profits, and some of these returns they are investing in a profitable and productive manner, that is, in caring for those who labour to make the profits.

At Mülhausen there is a workmen's colony which was founded in 1850 to improve the conditions of the workmen of the town. It consists of about 1000 houses with small gardens, which were sold to artisans at about cost price. The district at the present time, however, is hardly in the best condition, and many of the houses are untenanted, because it is said the workmen are anxious to live outside the town, and to travel into town in the morning by train. There are baths, wash-houses, and schools in the colony, but at the time of the author's visit the whole appeared to be a mixture of disorder and small businesses, only a part of the houses being used as originally intended.

Returning to the German colour-works, we find in the technical departments chemists engaged as analysts, as research chemists, and as technical men. The first class of

chemists deal with the work materials and products: they also analyse the products of other firms and attempt to detect infringements of patents. The research chemists are under the direction of such distinguished chemists as Duisberg and Bernthsen. A list of the chemists who have been employed from time to time by these works shows that the best brains have been attracted, and the same conclusion is formed as to the present state of affairs when one surveys the list of distinguished chemists who came from Germany to England for Sir W. H. Perkin's coal-tar jubilee.

The technical men are concerned with the dyeing properties of the different dye-stuffs produced. In this department all their own products and the products of other firms are tested. As soon as a dye-stuff is put on the market by a rival firm it is first analysed and then investigated as regards its dyeing properties by one of the technical staff. A conference is called, at which the technical man reports on the characteristics of the new colour, and suggests one or more of their own colours or mixtures of colours which can be used in competition with the new article. The travellers are then provided with this information in order to compete with the new product; if one of their customers mentions the advantages of the new product, the travellers are ready with the information to convince him that by mixing their —BX with a little —BR he can get the same result at less cost.

The chemists who investigate the dye-stuffs as above mentioned are generally university graduates, who, on entering the works, are trained to become technologists or to go out as representatives of the firm. Some of these men are sent to all parts of the world as special travellers, while others attain positions as superintendents of the different departments. Most of the heads of departments and many occupying high positions in the actual manufacture of the colours have gone direct from the university into the works, and the advantage of employing university men is well shown. No industry employs more university graduates, and no industry is more prosperous. These university men gradually rise to occupy the highest positions. A "good practical man," as the saying is in

England, might discharge the duties very well, but as a rule he is not imaginative, and he cannot suggest improvements or keep in touch with progress through the technical journals.

University graduates are received for training as technical men at a salary of about £100 a year, and a contract is made for one year. If during that year satisfaction is given, their salary is gradually raised during a period of five years, for each year of which a separate contract is entered into. Most of the servants of these works are under similar contracts. If any breach takes place between employer and employed, the latter is not allowed to enter the employment of a rival organisation during a period of two years after the breaking of the connection, but during this time he receives his salary from the firm. In this way a man, who has gained some special information in a department, cannot immediately place that information at the disposal of a rival firm; and after the two years agreed to, the information, owing to the rapid progress of the industry, may be of little use. During the first year or more the men engaged as above mentioned merely collect information, and are of little direct use to the firm employing them. It is true that they have to report on various products as before stated, but most of their time is taken up in gathering as much practical knowledge as they can in order to fit themselves for subsequent duties. They are for the most part left to themselves; they use the splendid libraries which many of these works contain, experiment as they wish, and learn as much as possible. In fact, this training is somewhat similar to the instruction provided by technical schools. The men meet periodically, when anything new in the chemical world is discussed, and the technical papers are passed round. In this way all are kept in touch with progress in the industry.

The actual dyeing is performed in a laboratory containing some dyeing machinery, which is worked by labourers to the directions of the technical men. Some modern machinery is used, but it is more or less on an experimental scale, and simply used to test the different dye-stuffs.

In fact, the whole training of these technical men is designed because of the lack in Germany of good dyeing schools. A graduate of a university rarely enters the trade schools, so that the colour-works have to provide the training themselves. But in England, where we have excellent schools of dyeing, these schools could be used in place of the experimental departments named, and a student who has gone through a training in dyeing at a good technical school would require little further instruction before being called upon to discharge the duties for which the German technical men are trained. The author speaks from experience when he says that a university graduate can learn as much by a year at an English technical school, as he could by a year's employment in a technical department of a German colour-works as described. Indeed, if it is contemplated that technical men be employed in connection with the new British dye scheme, the right men to engage would be those with university training, together with some technical school or industrial experience.

After the technical men have been engaged a certain time at the duties mentioned, and when the directors think that these men are sufficiently trained, they are sent into a works in order to obtain some industrial experience, that is, if they have not previously obtained this experience. If a man is intended for travelling in England, he is sent to an English works which is on good terms with the colour-works, and in this way he learns in about six weeks' time a little about the organisation, equipment, and occupation of the works, which some day he may be called upon to visit for business purposes. On completion of this training the technical man returns to the experimental laboratory, and after a short time he is ready to carry out the work for which he has been trained. Some of these men travel in districts near the works, returning perhaps weekly, while others go abroad. All the travellers visit the works from time to time, but in the case of those working, for instance, in America, the visits are of course not frequent. These men are also sent out when technical difficulties are experienced at the different works with which the colour firms do business. For instance, at a

certain print-works the chemist died, and it was found impossible to carry on the business without him. During his lifetime he had kept secret all his recipes, and he had different signs for different materials, so that when he suddenly died there was no means of finding out in what way and with what materials he had made the various "mixings" used by the firm. The works was at a standstill, so they applied to one of the colour-works for assistance. One of their technical men was sent, and after three weeks' hard work all was in order again. But there was one difference between the new circumstances and those previously prevailing. The chemist in making up the new recipes had used only the colours of the firm who sent him, so that by this means the trade in dye-stuffs and some other materials was diverted to his firm.

A large staff of research chemists is employed at each of the works. Their remuneration is only moderate, but successful work leads to increased earnings; patents are taken out by the firm, and if successful the inventor gets a share of the profits. In this way many chemists are drawing large amounts, and this system certainly incites the men to their best efforts. The preparation of a new dye-stuff is usually entered into after the constitution of that dye-stuff has been found, just as the formula for indigo was discovered before it was prepared on the large scale, and the whole series of magenta colours were produced by introducing groups of various kinds into the triphenylmethane nucleus; but in the case of sulphur colours, whose constitutions are not definitely known, new colours of this series are not produced with the same certainty.

The different colour firms aim at producing a variety of products, because business obtained for one product may lead to other business. For this reason, the travellers of some colour firms have been known to urge their employers to either make indigo or to sell the natural variety in order to satisfy all classes of customers.

In the works, each man is confined to his own department, and is in no case allowed to visit other departments. Men occupying high positions are known to have never been in any other part of the works than their own small building. There is a case on record of a chemist engaged

at a school who used to speak against the products of one colour firm. This firm gave him a good position in order to keep him quiet.

As regards the experimental dye-houses of the different colour-works that at Hoechst (Meister, Lucius & Brüning) is about 30 yards square, and is fitted with small machinery, pots, and other requisites for dye trials. Round the sides of this laboratory, and connected with it, are smaller laboratories, which are devoted to special purposes, such as cotton, wool, and silk dyeing, paper dyeing, indigo dyeing, etc. A large number of chemists are employed, and here, as at other German works, Englishmen were seen. In the indigo room the familiar spider-web-like hexagonal frames were used for dyeing piece-goods. Volunteers (see pp. 87 and 147) also work in this department, and they have good opportunities for learning. Just previous to the author's visit to this works, one of the technical men had invented a machine for dyeing cotton cloth a series of colours which blend into one another. The machine consists of a pair of rollers, between which the cloth passes; the lower roller, instead of being in one piece, is divided into numerous sections, the sizes of which vary, and each section fits into a separate small trough. The machine is like the ordinary padding machine, except that the box and the lower roller are in sections. Different dye solutions are placed in the different sections of the trough, and in this way the cloth is dyed differently at different parts. If different strengths of the same dye liquor be used, beautiful blendings are produced, and the variety and perfection of the effect depends on the number of sections in the trough. Another box, exactly corresponding to the trough used, is employed for adding the dye liquors to the trough. Many varieties of the machine are at work, and it is made by Haubold's of Chemnitz.

In Cassella's laboratory they have cop-dyeing and other machinery. A French modification of the Mather and Platt steamer is used. Cassella's printing trade is growing rapidly, and consequently their experimental printing department shows the same change. Their experimental laboratories appear to be well conducted, but they are old. In the different machines some patterns are dyed, but

most of these are obtained from manufacturers using their dye-stuffs. The youths who labour for the technical men begin the work while very young, and after a time attain such skill that they can carry out the dye trials without direction. Their wages are very small, as the work is quite mechanical. The weighing out of the dye-stuffs is done in a separate room, usually by girls. Some youths are engaged entirely in testing the fastness of dye-stuffs to washing, reagents, etc. Manufacturers send a pattern with instructions that the dye-stuff required must be as fast as that used for the pattern; this request necessitates tests for fastness, and it is a good principle that this firm never relies on any previous trials. In testing the strength of a dye-stuff and comparing it with a pattern, all the dye-stuff is salted out of solution on to the material, and afterwards another piece of material is put into the bath to show whether it is exhausted; this second piece of material is attached to the first piece when making a judgment of dye-stuff strength.

In the laboratory of the Badische works there is a machine in which cop-dyeing is done by frothing, a Pornitz cop-dyeing machine, and an Obermaier machine for treating loose fibres. Felting tests were done by working the material along with soap between two wooden slabs. In testing the strength of dye-stuffs used for dyeing paper pulp, a certain amount of pulp is mixed with a solution of a certain amount of the dye-stuff and stirred by means of a vertical stirrer. The pulp is then filtered by pressure, and the paper thus formed is first dried between absorbent paper and then in a steam bath before comparing the strength of the dyeing thus obtained. In the leather-dyeing department skins were shaken with solvents to extract the fatty matter, and then dyed back to back to prevent the flesh side from absorbing the dye-stuff. Sometimes the skins were dyed by merely painting them with a solution of the dye-stuff. Leather was also seen in process of dyeing, and afterwards polished in a machine provided with a small smooth roller, which revolved against the surface of the leather.

At the Berlin Company's works they have a neat milling machine, the material being moved backwards,

forwards, and sideways during the process by means of rods operated by different eccentrics. The walls of one room were covered with small drawers, which contained the products of competitors ; each firm finds it necessary to learn as much as possible concerning the productions of its competitors.

The large German works contain departments in which men are taught to dye their products in all possible ways. These departments are called "volunteer laboratories," and those receiving instruction are either sons of manufacturers, or in some other way connected with, or about to enter, the dyeing industry. This scheme is advantageous to both parties concerned. In the first place, the firm profits because the volunteer learns to dye his colours thoroughly; and, since he is under contract not to volunteer with another works for one year, he afterwards uses in practice the colours he has learned so much about. Then the student gains in general knowledge, for he learns to dye materials which, perhaps, he has not seen before. Thus, he can learn the dyeing on the small scale of cotton, wool, half-wool, wool and mercerised cotton, silk, half-silk, jute, linen, ramie, artificial silk, shoddy, etc. He is placed under a competent chemist, and, as he also has a fine library at his disposal, he has every opportunity of acquiring knowledge. He also has the opportunity of keeping in touch with the scientific journals, for in this way one learns the latest discoveries in technology. In some works the volunteers move freely in the technical laboratories, but in others they are kept to their own department. From time to time discoveries, which have been made as regards dyeing, are tested in these laboratories, and men pay periodic visits from different works in order to keep in touch with progress in their industry. By means of pattern-books and note-books the volunteers keep records of their work, and these notes subsequently prove useful in industry. Moreover, by meeting young dyers of different nationalities in these departments, one gets an idea of the nature of the dyeing industry in different parts of Europe.

CHAPTER XIV

COLOUR PRODUCTION (*continued*)

In the previous chapter, which has been left practically as it appeared in the first edition, some aspects of the colour industry have been discussed. For instance, the effect of war between this country and Germany was alluded to, and the chaotic state which would thereby result. As regards the compulsory working of patents we have recently had legislation on this matter, but it is evident that the new Act has been so evaded as to make it practically useless. The author mentioned this possibility, and the outbreak of war has revealed the methods used by the Germans to evade the law. In the United States compulsory working is not demanded of patents, because they regard such legislation as incapable of achieving its purpose. Then in reference to the production of new colouring matters the author pointed to the possible exhaustion of the field, and it is significant, in looking back over the last ten years, that relatively few discoveries of an important nature have been made in coal-tar colour chemistry. The discovery of Thio-Indigo Red, before the decade mentioned, led to the production of other vat colours, such as Thio-Indigo Scarlet, the Algol and Ciba colours, and then many new brands of older classes were introduced; but the range of colours has not been very much extended. In fact, dyers who use no colours which have been discovered during the last ten years may be prominent in their industry. Indeed, in this country, many large works still use wood colours in large quantities, particularly for yarn, and they are not inclined to give up their use. It can therefore be understood that, as the patent rights of the important aniline colours run out, the

aniline dye industry will assume another aspect. As previously mentioned, the Germans have recognised this possibility, and have disguised their patent specifications so as to give little information as to the method of production of the patented articles. Moreover, they have turned their attention more and more towards the production of other synthetic products, as photographic and pharmaceutical articles. After a long run, and when this branch is played out, they will no doubt find some other branch of remunerative activity.

The German aniline colour industry has been so much discussed in this country of recent years, and at present is receiving so much attention, that one is apt to lose all sense of proportion in regarding it. It must, however, be remembered that this industry is only a relatively small part of the total chemical industry of any country. Indeed, if the chemical industry as a whole be considered, it will be found that, as regards the value of chemicals produced per head of the population, Great Britain is not far, if at all, behind Germany. On this point the author wrote the following remarks in a letter to the *Manchester Guardian* in 1910: "As for the German colour industry I have long contended that it has too often provided food for those Britishers who are always stating that we are falling behind in the industrial race, and the fact that this industry is again brought to our notice only serves to point to the paucity of more suitable material to brood over. Even though the dividends declared by the German colour-works are high, it must be remembered that there are still many English chemical concerns which are the envy of German manufacturers. For instance, to-day I received a German paper that contained an advertisement for a chemical commodity which is made not far from Manchester. This article is made by a firm whose enterprise is world famous, whose capital is as big, I think, as all the German colour-works put together, and whose profit in normal times is very large. This is merely one concern in one British industry, but such facts are often overlooked when generalisations are made."

Although Germany is foremost as regards the production of synthetic dyes and some fine chemicals, it must

be remembered that our heavy chemical industry is of great importance, and that we also produce large quantities of fine chemicals of prime importance. Thus, as regards alkaloids, Germany was our principal customer before the war. Then, more morphia is produced in this country than we require for our needs, and caffeine is made to an enormous extent. Chloroform is produced in large quantities and exported to all parts of the world. As regards synthetic drugs, it is true Germany has produced some articles of value, but at one time hardly a month passed without some new drug with a scientific name being introduced to English medicine. The new products differed only slightly from those previously used, and few were of value; they only served to cause annoyance to medical men. Moreover, the few of these drugs that are of value can be made in this country without much difficulty. It has also been pointed out that some drugs which were discovered in this country have been given high-sounding names by the Germans, and by this means the trade in these articles has been diverted to themselves.

It is recognised that, except as regards synthetic dyestuffs, synthetic drugs, and fine chemicals, the English chemical industry has held its own; but it is also manifest that the Germans are now turning their attention to the capture of the heavy chemical trade, for their exports of sulphuric acid, cyanides, etc., are increasing.

There is no doubt, however, that the German aniline colour industry, as explained in the previous chapter, has been a great industrial asset to Germany, because it has become the mother of many new industries, such as synthetic pharmaceutical products, anhydrosulphuric acid, and liquid chlorine; because the industry has been a great object-lesson to the Germans in showing the advantage derived from the application of science to industry; because it has reacted in producing a more general appreciation of technical education; and because it has been an important factor in inducing the Government and local authorities to render assistance in fostering various industries. Co-operation among factories in Germany enables different syndicates to obtain facilities from their Government which we cannot obtain here, and this lack

of cohesion among our chemical manufacturers creates a tendency to compete unduly with one another, whereas some system of co-operation and control, such as they have in Germany, would be of value both in cheapening working costs and in regularising output.

In 1913 the number of coal-tar dye-works in the world was: Germany 22, France 11, Great Britain 11, United States 9, Austria-Hungary 4, Switzerland 4, Holland 2, Russia 2, Belgium 1, Greece 1, and Italy 1. Sixteen plants, which at one time made coal-tar colours, have abandoned the manufacture: 11 in Germany and one each in Austria, Belgium, France, Great Britain, and Switzerland. Fourteen have been absorbed by other factories: six in Germany, four in Switzerland, two in France, and one each in Holland and Belgium. These figures do not give an idea of the relative importance of the different countries in the dye-stuff industry, but the following returns give some idea of the eminence of Germany's trade. The values of coal-tar dye-stuffs imported into the United Kingdom, India, and Japan from Germany in 1913 were :—

	United Kingdom.	India.	Japan.
Alizarine and anthraquinone dyes	£271,119	£140,279	£[illegible]
Aniline and naphthalene dyes	1,382,478	339,248	[illegible]
Synthetic indigo	76,681	37,412	304,052
Other kinds	543	...	...
	£1,730,821	...	...

China imported synthetic indigo from Germany of the value of £575,000.

On the outbreak of war the stoppage of imports from Germany placed users of dye-stuffs in an anxious position. Substitutes were found in some cases, and it was remarkable to find how often other colours and pigments could be used in place of the usual dye-stuffs. Wood colours were more used, and the Swiss firms assisted matters considerably ; but at times such colours as basic blues, basic violets, and acid violets were practically unobtain-

[illegible] THE PRODUCTS AND DYE-STUFFS IN 1913 [illegible] METRIC TONS)

[illegible]	[illegible]	[illegible]	[illegible]	Aniline Dyes.	Various Alizarines.	Alizarine Red.	Indigo.	Net Totals.
[illegible]	[illegible]	[illegible]	365	13,835	2,164	493	3,461	24,004
[illegible]	[illegible]	[illegible]	34	10,793	1,130	1,493	1,180	15,235
[illegible]	[illegible]	[illegible]	281	5,582	223	207	1,361	7,975
[illegible]	[illegible]	[illegible]	825	4,097	158	...	662	6,392
[illegible]	[illegible]	1,217	968	1,098	156	174	434	4,579
[illegible]	[illegible]	[illegible]	708	2,700	96	...	313	3,037
[illegible]	[illegible]	[illegible]	778	1,301	124	98	323	2,839
[illegible]	[illegible]	[illegible]	1,261	941	...	259	...	2,008
[illegible]	[illegible]	[illegible]	5,123	38,185	3,605	2,724	7,734	66,069
[illegible]	[illegible]	[illegible]	11	32	12	9	21	...

[illegible] those in the trade it has been really wonderful [illegible] the reasonable requirements of the public have [illegible] the textile trades during the unforeseen circumstances arising out of the war. Those engaged in [illegible] have, of course, been reticent as to their methods of [illegible] and their means of overcoming the difficulties which have arisen. Publicity as to these matters would have served no good purpose, and might even have been harmful from a national point of view.

When the war broke out it was evident that the stoppage of the imports of aniline dye-stuffs from Germany into this country would have a big effect on a number of our industries, and the matter engaged the attention of the Government. The President of the Board of Trade appointed a Committee to investigate the matter, and an Intelligence Branch was opened to bring together buyers and sellers of articles hitherto imported from enemy countries. Acts were passed to extend the powers of the Board of Trade as regards patents during the continuance of hostilities. The exportation of dye-stuffs from this country was prohibited by decree dated September 8, 1914, but a further Order of Council granted licences to certain firms to export certain dye-stuffs. On September 15 the German Government also issued a decree prohibiting the

export of dye-stuffs and tar products, but it is known that since that time both intermediate products and dye-stuffs have been exported to Switzerland and thence to other countries. In fact, the Germans later threatened to supply the Swiss with no further products if these were exported to England.

In November 1914 the Board of Trade, after consultation with the Committee appointed, deemed it advisable to take such steps as were possible to develop the immediately available sources of supply, and also to encourage the permanent manufacture of dye-stuffs in the United Kingdom on the large scale, so as to guard against any recurrence of the present difficulty. Arrangements were made to encourage the immediate expansion of the various existing sources of supply, and, as regards the permanent supply, after consulting representatives of various colour-using industries, a scheme for the formation of a limited company was devised, the bulk of the capital of this company to be subscribed by the consumers of dye-stuffs and others interested. The Government indicated their willingness to subscribe a certain proportion of the share capital, and to guarantee the interest on a large debenture issue for a term of years. It was pointed out that the trouble was not a temporary one, for after the war the two large German combines could so dominate our great textile industry that they could overcharge and hamper it pending the time when they could challenge its very existence. The share capital of the new company was stated at £3,000,000 divided into 3,000,000 shares of £1 each, the Government to advance to such company £1,500,000 bearing interest at the rate of 4 per cent per annum and secured as a first charge on the assets and undertaking of the company, and to be repayable in twenty-five years. Arrangements were made with Read, Holliday & Sons, Ltd., for the extension of their plant, and later, this works was taken over by the new company. The Government stated that they should have the right of appointing two directors, and that they considered co-operation could best be secured by the subscription of the share capital by those interested, and also by a contract being entered into between the company and the con-

sumers and users of the products, whereby the consumer should agree for a period of five years after peace is established to take supplies from the company in all cases where the company is able to supply the same of good quality and at reasonable prices, but with the provision that, if the consumer thinks that the prices charged by the company are too high, he may require that the prices charged shall be determined by an independent referee. With the object of securing for the company impartial administration, the Board was chosen by the Committee, and was mainly composed of business men who were not themselves necessarily engaged in the dyeing trade. An Advisory Committee was formed, mainly from representatives of users of dye-stuffs, and in addition the Board had the advantage of the advice of chemical and other experts.

The scheme met with much opposition. For instance, the Leeds Chamber of Commerce suggested protection for the new industry by means of import duties, and, later, stated that the Government scheme would not meet the needs of the situation, but would stifle competition and establish a monopoly; the Council of the Associated Chambers of Commerce supported the Leeds Chamber; the London Chamber of Commerce asked for protection for ten years after the conclusion of peace; the Manchester Chamber of Commerce expressed itself against protection for the new industry; and the Derby Chamber of Commerce preferred private enterprise to a Government undertaking, because small undertakings to manufacture at first quite a limited number of colours would, they thought, be more successful than one large concern. They further stated that the movement would be assisted by co-operation between gas works, tar distillers, alkali works, etc., for the purpose of advancing the crude products another stage. Objections were also raised in other quarters. Many firms hesitated to bind themselves under the contracting clause, which compelled them to buy only from the new company, owing to their doubts as to the ability of the company to produce dyes of the requisite quality and at a suitable price. Moreover, the subordination of science to business was considered by some people as a weakness of the scheme, since it was thought that science

should govern the directorate. Resignations from the Board took place because of differences, but during this criticism it was pointed out (1) that the Government only lent their assistance because private enterprise had not taken the matter up, and (2) the co-operation of the users of dye-stuffs was required because, if the users and the allied trades resolved that never again would they be placed in such jeopardy, the Germans would be powerless and the British company unassailable.

Opposition, it was said, came principally from the three largest dyeing concerns in the country, and it was stated that these works could look after themselves, whereas the smaller works could not. The success of the scheme depended largely on the manner in which the German patents were administered, and the Government stated that it was their intention not to cripple the company after the war was over, but to give it every opportunity of making the most of those patents. The Government left open for discussion the payment of royalties in respect of these patents, but it was stated that the operation of the patents undertaken by the new company would be allowed to proceed after the war was over without interruption or hindrance. The grant of £100,000 towards research was stated to be really a grant towards assisting technical education. Against the criticism that no chemist was on the Board, it was urged that many chemical concerns had been ruined by having highly gifted scientific men on their Boards.

The result of the criticism was that the Committee was altered and a modified scheme introduced. The financial basis of the company was also altered, and the agreement to be entered into between users of dyes and the company was considerably modified in favour of the users. On March 27, 1915, sufficient applications for shares had been obtained to enable the Committee to decide to go on with the company. A research department was afterwards formed, and a Technical Committee and a strong Advisory Council nominated. It was stated that the output of Read, Holliday & Sons' works had been doubled since the taking over by the company, and further plant was in course of erection. It was essential to increase largely

the capacity of the plant for the manufacture of intermediate products, and to this end a new works was established near Huddersfield.

In America, at the outbreak of war, the position was very similar to that in this country. They had also been dependent on Germany for supplies of dye-stuffs, and with the stoppage of imports they, like ourselves, had to seek other means of obtaining these products. The authorities at Washington tried to make arrangements for importing dye-stuffs from Germany, but without success. It was pointed out that other countries would not require the stocks of dye-stuffs held in Germany, and, if means of transport could be found, American mills would thus be enabled to run for another year; otherwise, it was predicted that many of the mills would be forced to close in sixty days.

It was soon, however, determined to proceed to the manufacture of dye-stuffs. No Government assistance was required, but of course the circumstances in the United States were different from those prevailing here. In our case the chemical manufacturers were busy with explosives, from which they were making big profits, so that there was little inclination to take up a branch of manufacture which required much expensive plant and of which the profits were by no means so certain. At first it was stated in America that it would be exceedingly difficult to establish a coal-tar dye-stuff industry in that country, because the German industry was so dependent on interlocking chemicals; it had reached such a state of complexity and interdependence that it would be very difficult to translate it as a whole. As regards the chemical and engineering work, no difficulty was expected, for it was stated that the production of a useful illuminating oil or a medicinal preparation from crude petroleum compared very favourably in technical manipulation with the production of most coal-tar dye-stuffs. Moreover, the petroleum products were of greater economic value. It was pointed out that to establish a complete coal-tar dye-stuff industry, 700 different dye-stuffs would require to be made, and to be made properly, as good qualities of the same products would be in competition on the market.

It was one thing to develop such an industry and to maintain it against newcomers, but another to build it up in the face of competition and to hold it against those who developed the business, knew all its ins and outs, and had their experience bought, paid for, and written off long ago. For America to be independent of Germany as regards dye-stuffs, it was urged that the intermediate products must be made on a large scale, and to do this they would require a protective duty sufficient to allow the trade to be developed. The present duty of 10 per cent was stated to be insufficient protection, because of the convention which controlled the industry in Germany and immediately reduced prices by the amount of the tax. The unfair competition of Germany could be easily checked, if the Government would incorporate in their tariff what was known as the "dumping clause," which forbids the importation into, and the selling of, in the United States of any products at a less price than they are sold in the country where they are produced. The manufacture of explosives would increase the consumption of intermediate products, for no country would care to be dependent on a foreign supply of toluol or carbolic acid. In self-defence, it was urged that some sort of a tariff should be created to protect the industry.

The experience of the Benzol Products Company, which started in a small way to manufacture aniline oil, was that, although a tariff of 10 per cent was placed on aniline oil by Congress, foreign manufacturers reduced their prices to a point where it was impossible to compete. Similarly in England the manufacture of alpha and beta naphthol and of H and G acids had been hindered because the Germans dumped down their large surplus.

There was a movement on foot in 1909 to revise the American patent laws on the lines of recent British amendments, but Germany negotiated a treaty, by which the German compulsory working clause was made inoperative on American inventions. But in America changes of the patent laws are not regarded of importance to the dye-stuff industry, for there are quite enough dyes on which the patents have expired to constitute a large industry. A committee of the American Chemical Society reported

that changes in the patent laws, such as compulsory licensing or compulsory working clauses, were wholly ineffective, do more harm than good, and should not be attempted.

From 1880 to 1883, when there was a duty of 35 per cent *ad valorem* and 50 cents per lb. specific, there were ten dye factories in the United States. In 1883 the specific duty of 50 cents was abolished, and within one year, it is said, five of these factories succumbed. Now only five were left, and these had had a great struggle to maintain themselves. It was stated that America could manufacture dyes, if it were made commercially possible; but, whenever conditions became normal again, it was thought that the manufacture of intermediate products would not be successful, because these products could be obtained very cheap from Europe.

A further opinion was that whether an American dye-stuff industry arises or not depends on the consumers of the dye-stuffs. They have the materials, the technical knowledge, and the capital, and there are sufficient unpatented dyes to make nearly everything needed. Protection is necessary and will increase the prices of dye-stuffs for a time, but this increase in price will be an absolutely negligible item on the cost of dyed goods, and, when the industry is once established, protection will be no longer necessary. Consumers of dye-stuffs merely require to petition Congress that they want an American coal-tar dye industry.

The New York section of the American Chemical Society reported that alterations in the tariff are necessary to introduce the manufacture of explosives, medicinals, chemicals, and dye-stuffs in the United States. The United States produces sufficient quantities of raw products to supply a self-contained industry, and such an industry could be brought into being if there were a certainty of output in the nature of a demand from the home users. To be independent of all foreign nations at all times as regards the supply of explosives, or to protect the textile industries using chemicals and dye-stuffs and make them independent of foreign nations, the nation must bear the burden incident to such expansion. The Committee

recommended: (1) to prevent the unfair underselling alleged to be practised by foreigners in the United States, an effective anti-dumping clause should be adopted; (2) the so-called coal-tar intermediate products, which are the basis of the coal-tar chemical industry, inclusive of explosives, medicinals, and dye-stuffs, should be taxed one-half of whatever the finished dyes are taxed for tariff purposes, all coal-tar dyes without exception to be taxed alike, namely, 30 per cent *ad valorem* and 7½ cents per lb. specific.

At the beginning of the war the United States was in a fair position as regards intermediate products, such as aniline oil, aniline salts, beta naphthol, and para nitraniline, but the growth of this industry depended on the supply of benzol. Very soon the supplies of benzol became great, for in April 1915 Pittsburg was producing 20,000 gallons of benzene daily, the United States Steel Corporation 12,000 gallons, and other plants were being erected. The Benzol Products Company laid down a large works for the manufacture of intermediate products, and another company began the manufacture of sulphur colours. The Cambria Steel Company arranged to manufacture dye-stuffs from six tons of benzene and its homologues yielded daily by their coke plant. Other firms established plants for making dye-stuffs, and existing plants were extended. The daily output of benzol from coke works was brought up to more than fifty tons, but the manufacture of intermediates was hampered by the demands for benzol and toluol for explosives. The output of the works making intermediates is now sufficient to meet the needs of American dye-stuff makers, and other works are being erected. Two new companies have been organised for the manufacture of coal-tar products, and the other works have increased their plants for the turning out of finished dyes. There is now a steady increase in the output of American made coal-tar dyes. The large works at Buffalo are running night and day, employing 600 operatives. The volume of the output is at least double what it was before the war. Manufacture is concentrating on a few staple dyes, which are chiefly in demand, and the lack of which would be severely felt by the great textile interests. A new direct black has been

produced, which is capable of replacing aniline black to some extent, and also some new sulphur blues. The Bayer Company's works, after being closed for some months, has now reopened and resumed the manufacture of nigrosines, alkali blue, and a few other colours. Instead of getting their intermediates from Germany as formerly, these are now made from crude American products. This firm is also making some of its pharmaceutical specialties.

The combined efforts of these works will certainly relieve the situation somewhat, but it is stated that at the best they can only replace for the next few months a relatively small quantity of the lacking colours. The firms devoted to the production of dye-wood extracts are making ample preparation for meeting heavy demands during the next few months; increased attention is being devoted to quercitron, the only natural dye-stuff indigenous to the United States.

As the result of representations made by various interests, a Bill has been introduced into the House of Representatives with a view to the protection of the American dye-stuff industry from foreign competition. All substances produced in commercial quantities by the destructive distillation of coal, and are not themselves dye-stuffs, are to bear a duty of 5 per cent *ad valorem*. The duty on "intermediates" made from these substances is to be 3¾ cents per lb. and 15 per cent *ad valorem*, and on the finished dye-stuffs 7½ cents per lb. and 30 per cent *ad valorem*. Coal-tar, wood-tar, acetic acid and other acids, and natural indigo are placed on the free list.

In Japan it was reported that stocks of dye-stuffs were very short at the beginning of the war, and that the situation was very exacting. Previously they had imported dye-stuffs of the value of £700,000, chiefly from Germany. As most of these dye-stuffs were used in the important textile industries, and as prices advanced rapidly, the Government introduced a Bill granting subsidies to companies making dyes and chemicals in Japan, provided that more than half the capital was subscribed by Japanese subjects. The amount of the subsidy will be sufficient to enable the companies to pay 8 per cent on their paid-up capital. Attention was also devoted to

the cultivation of the indigo plant, a very old Japanese industry. Later, three companies were organised with a view to obtaining Government subsidies. One company, engaged in the manufacture of glycerin, with a capital of 3,000,000 yen, intends to take over the business of an oil company at Osaka. The second company, manufacturing medicines and chemicals, intends to specialise in the manufacture of formalin and its derivatives, and in other carbon compounds. This company will have a capital of 500,000 yen, and will acquire the works of an existing Japanese concern engaged in the production of acetic acid. The third company produces medicines, and will have a capital of 1,000,000 yen. The Japanese Government has arranged to form a company for the manufacture of dye-stuffs, with a capital of 8,000,000 yen. The first works will be built in Tokio or Osaka, or in the north of Kuishin (probably close to the Wakamatzu ironworks, whence the necessary benzol will be obtained).

In Russia a syndicate was formed, composed of some of the largest industrial concerns, for the establishment of works for making dye-stuffs and for the erection of special research laboratories. The assistance of a number of technical chemists from Switzerland was obtained.

One of the reasons attributed for the failure of the French to establish a coal-tar colour industry is the patent legislation, according to which a new substance may be made the subject of a patent, so that the inventor of a much preferable method of production is unable to work the new process until the patent for the substance itself has expired. Many examples of such hindrance are known. For instance, the indanthrenes, an important class of dye-stuffs, were discovered and patented in France, but were eventually marketed by German firms because the original process of production was less economical. Prohibitive fiscal measures will not of themselves, it is said, assure the building up of a coal-tar industry, for success in this direction depends more on educational and commercial considerations. Then there is the difficulty of distinguishing for fiscal purposes between raw materials, intermediate products, and finished products. For example, the colourless leuco bases of triphenylmethane

dye-stuffs have been admitted to France as intermediate products.

The manufacture of dye-stuffs is now established at Paris, Nancy, and Lyons, and extensions of the works have been decided upon, but at present there is a shortage of crude tar products, which previously were imported from Belgium, Great Britain, and Germany. It is not regarded as probable that sentiment will play much part eventually in the purchase of dye-stuffs; hence it will be essential to offer colours at practically the same prices as German firms. The manufacture of colours, for which the patents have expired, can be taken up, but this business is not very remunerative, because such colours are generally low in price since the patentees have made their profit out of them and further developed their plant and process. The attraction of chemists trained in the production of dye-stuffs was a difficulty, but it was thought that some assistance might be obtained from Switzerland such as Russia had obtained.

It is the author's opinion that the enterprise of British Dyes, Ltd., will be a great success. Moreover, the value of the German dye-stuff industry will decrease as the industries of England and America, hitherto Germany's best customers, increase. The establishment of the aniline-colour industry in this country will also give the public a concrete example of the value of science to industry, and will prevent politicians from pointing to the decadence of England as instanced by the aniline-colour industry. By providing employment for trained chemists it will also react in helping the universities and technical education in general.

There seems to be a consensus of opinion that after the war prohibition for a time of German imports, and then a high tariff, will be the only way of protecting the industry. While in Germany the author was often told that a tariff put on German manufactures by England would have meant war between the two countries, but such a consideration is not now of interest. Certain it is that, from what has been stated above, some protection will have to be provided for the new enterprise. Free Traders have always admitted that protection is sometimes

of advantage in developing new industries; in this case international trade will have to be arranged with the military situation in view. But it might not be advantageous to our textile industries to exclude all German dye-stuffs after the war, because this procedure might affect us in competing in foreign markets. For instance, such colours as Bayer's alizarine brands may be found difficult to make, and if kept out of this country may be a handicap to our textile industries. A great deal will depend, however, on the progress made by British Dyes, Ltd.

Mr. Runciman, the President of the Board of Trade, in the House of Commons on January 10, said: "Of course we could not go on with our trade treaties in the same way after the war. Some of them did the Empire grave injustice. The working of the most-favoured-nation clause had operated increasingly to our detriment in recent years under the arrangements made between Germany and Russia. We could not permit at the conclusion of the war the outbreak of another economic war by Germany against us. Our own national and commercial interests must in all these matters be our first and only guide. Some industries were almost entirely in the hands of Germany before the war. We were now producing optical glass and a large number of chemical articles which previously were almost entirely in German hands. The same thing applied to dyes, electrical apparatus, and other articles. We had been placed at a great disadvantage owing to the lack of these articles in this country. Never again should that happen. There should be no essential article, either for the arts of peace or war, which we could not in the Empire lay our hands on. Progress in this matter did not depend on Government assistance. Government departments could do a great deal, but without the personal ability, training, skill, and knowledge of the individual nothing could be done. The first interest of this country was to improve the training of our own men, and we should not attempt to economise in this direction. The next quality was that of adaptation. The war had taught the commercial people of this country the necessity of adaptability." He

agreed that there should be an extension of commercial banking as distinct from the more conservative form of banking business. Manufacturers and commercial men were at a disadvantage as compared with those in Germany who were in touch with more adventurous institutions. Our banks must be more enterprising. If they could not, then we must have some additional institutions.

He also agreed that we must overhaul our patent system. However much we might help industry by changes of policy, there was no doubt that the development of new inventions, and restrictions put on their use, would have a greater influence on the extension of our trade and industry than even the juggling of a tariff.

Of the 700 or more colours made by the German works, only a small proportion need be made in this country in order to supply our wants during the war or, indeed, after the war. It is important to make large quantities of a few colours. Many of the German colours gained a market merely because of their cheapness, but price is not a vital consideration at present. Large quantities of the better colours are necessary. Research work will be principally required at first to ascertain methods of production of known colours, in order to prepare these products on the large scale, but afterwards work can be done in the way of discovering new compounds.

It has been stated that after the war large quantities of dye-stuffs will be made in America under German control, and that these dye-stuffs will be exported to this country; but it must be remembered that America will have to strive very hard to supply her own needs. If, however, she is able to export some dye-stuffs, our industry can be protected from these imports in the same way as it will be protected from dye-stuffs coming directly from Germany. There is no doubt that great efforts will be made in America to retain the industry which they are building up in war time; if an export trade follows, there are plenty of other markets to supply besides ours. We ourselves, in the meantime, had better give our whole attention to our own requirements.

In considering the aniline-colour industry it must always be remembered that through chemical research is

the road to success. The German and Swiss works, which have brought out the greatest inventions, are the principal works devoted to the industry, and their success has been due to the research work which has resulted in these inventions. The only way that our new industry can flourish is by developing in the same direction, that is, by employing research chemists from our universities. In the German aniline-colour works there are hundreds of research chemists trying the effects of introducing different groups into the molecules of known dye-stuffs, and by a variety of other more or less stereotyped ways preparing new organic compounds. New dye-stuffs produced are submitted to technical men for trial; some are found worthy of manufacture and others are rejected. And even if adopted they might be little used in industry. Now, if a large number of men are continually engaged in this work, it is obvious that some discoveries must result, although it must be admitted that there is an element of chance in the whole business. Moreover, when one considers that many of the best products of these works have been discovered outside the works laboratories, it is manifest that each one of the research chemists in the works cannot have achieved many distinct triumphs.

If our new colour industry engages a number of research chemists, an outlet for our organic chemists will thus be provided. The author has long maintained that it is only by such means that organic chemistry can flourish. In Germany the colour works employ large numbers of chemists trained in organic research, and in this way encourage the study of this branch of science. We must make organic chemistry a "bread-and-butter" study. If the new colour industry offers students, who have done research work in organic chemistry, a position at, say, £100 a year and a share in all remunerative discoveries, it will not be long before there is a large supply of organic research chemists. When students have finished their three years' honours course in chemistry at an English university, and have perhaps done a little research work, they look out for a remunerative appointment. In some cases a research scholarship is obtained, but the competition for these scholarships is keen, and it would be

much keener if the graduates could see some definite position ahead after the scholarship is finished. After the research work has been completed and published, these scholarships generally lead to minor staff appointments, and in some few cases to professorships. But the graduates who do not succeed in obtaining research scholarships have to find other outlets for their abilities, and the tendency has been in recent years for honours chemistry graduates to obtain positions as science masters at grammar schools, that is, to find refuge in positions which are not designed for them, and are more suitable for men who have taken the ordinary science degree. When these situations are obtained, the honours man certainly receives a living wage at the outset, but he finds that his opportunities of further advancement are few, for he has little chance of doing research work or of distinguishing himself in other ways. In short, his honours training has not been utilised as it should have been, and has had no opportunity of developing its true usefulness. This position has really arisen because of the few opportunities which are presented to the honours graduate of obtaining a living; for it must be remembered that there are comparatively few students in the chemical laboratories of our universities who can afford to study the science without giving consideration to the position to which the study will lead. If an outlet for these honours graduates can be found in the new industry, there will be a great impetus to the study of organic chemistry and a direct gain to the industry. In fact, by providing such positions is the only way in which the new aniline-colour enterprise can achieve success, and such an action will make it absolutely unnecessary for the Government to make lavish grants in aid of so-called research. Each position so granted will yield its own reward, and it is only by a commercial transaction of this nature that research and university chemical training can receive real assistance. These remarks also apply to other branches of chemical industry. The primary consideration is—get trained chemists into industry.

The study of chemistry in this country has hitherto opened the door to few employments, hence it has shown

a tendency towards becoming a kind of luxury dabbled in by those who liked it and could afford to pursue it regardless of profit. Under such circumstances the study could not flourish. Professor Perkin has lately mentioned his father's natural dislike for an industrial career and his desire to devote himself entirely to pure chemistry. That resolve proved to be of advantage to pure chemistry, but it was certainly unfortunate for our infant colour industry. It is still more unfortunate, however, that so many chemists in this country are ready to follow in Sir William Perkin's footsteps, for among scientific chemists connection with industry is not liked, and industrial work is looked upon as being of "merely technical" interest. Work known to have taken many years of hard labour, work scientifically carried out and sometimes of high importance to the community, has been overlooked because it was said it made no direct contribution to science. The result is that research students aim more and more at abstract research, and attempt to introduce higher mathematics into their work so as to squeeze papers into the transactions of learned societies, and thus receive recognition. They know at the outset that technical work will not advance them in chemical circles. This state of affairs cannot be of use in assisting the application of science to industry.

Another state of affairs which must be mentioned, and also deplored, is the feeling of distrust which exists between what are called scientific chemists and technical chemists. Although many scientific chemists refuse to have any connection with industry, this feeling does not prevent them from lecturing industrial chemists from time to time in an attempt to give them advice concerning industries of which they themselves have only an outside knowledge. These attempts, however, only lead to irritation. It must be remembered that there are many really distinguished chemists engaged in the industry of this country who have no university degrees and to whom contributions to the transactions of learned societies offer no attractions. It is in the interests of the co-operation of science and industry that a spirit of esteem should be engendered between the two classes of chemists mentioned.

As for the contention that in Germany the professors of chemistry are far more in touch with industry than they are in this country, the author found little evidence in favour of this view. For instance, he met Professor F. Haber at Karlsruhe, a chemist who has since become distinguished. Professor Haber was engaged on a number of researches at the time, and he gave the author a number of introductions to works in the district, but it was evident that at that time this professor was not in intimate association with industry. Shortly after the author's visit, however, Haber was brought into association with industry, but this event was a direct result of his discoveries. Such work would have resulted in industrial connection in almost any country. Again, take the discovery of salvarsan by a German professor, and its manufacture at the Hoechst Works. Can it be maintained that, if such a product had been discovered at an English university, a chemical works could not have been found in this country to take up its manufacture? In such cases as these, industrial connection was bound to arise: the merit of the discoveries brought about the connection. But it is only in such cases that we find a close connection between professors and industry in Germany. In England, however, we find professors openly stating that they have never done consulting work or had any connection with industry while holding their professorship, and this they consider a right position to take up. A chair at a university might be founded from money made in industry, but the professor holding the chair might refuse to have any connection with industry. There is no point in our scientists calling for co-operation between science and industry if they themselves do little to encourage the connection; for success in this matter can only be achieved by the urgent desire of both parties interested.

CHAPTER XV

COLOUR PRODUCTION (*continued*)

In 1914 a committee was appointed by the Society of Dyers and Colourists to compile a census of dye-stuffs used in Britain, and the Board of Trade continuing the matter have issued a report, which gives a list of the colours imported, together with the quantities and the makers' names. Each specific variety of dye is given; for instance, there are 155 distinct kinds of methyl violet, and it is pointed out that this multiplicity must cause needless expenditure in manufacture; accordingly British makers would be well advised to limit the umber to two or three varieties, leaving the consumers to alter the shade by admixture with other dyes.

Although about 10,000 colours are listed this quantity is really very much greater than the actual number of distinct dyes, owing to the use of multiple names for the same colour. Benzo sky blue appears under at least nine different synonyms. Moreover, many commercial dyes are complex mixtures.

In the summary of imports, the cheap direct cotton colours head the list with just under seven million pounds weight. This great vogue is due to ease of application rather than to the permanence of the dye. Chrome and other mordant dyes were imported to the extent of 6,477,065 lbs., while the extremely fast but expensive vat dyes total only 588,445 lbs. In all 18,000 tons of dyes came into England in 1913, valued at £2,000,000, and the industries depending on this importation had a yearly output of over £200,000,000.

Nearly the whole of the dye-stuffs mentioned came

from Germany, a small minority from Switzerland, and a few from France. The progress of dye-stuff manufacture during the war period has been well portrayed by Prof. G. T. Morgan in the *Annual Reports of the Progress in Applied Chemistry*, 1916–1918. For nearly sixty years prior to 1914, the manufacture of synthetic dyes had become increasingly a German monopoly. A few enterprises—notably those of the Swiss colour-makers—still continued the industrial struggle against heavy odds, but they were the honourable exceptions to the general rule. The line of least resistance more often followed by reputed dye-makers outside Germany was either to assemble German intermediates and convert them into dyes, or, more lucratively, to purchase finished German dyes, and, after breaking bulk, to purvey them, *cum grano salis*, to dye users at enhanced prices. The outbreak of war demonstrated to the general public of the allied and neutral nations two cardinal facts which had long been appreciated by chemists having expert knowledge of the coal-tar industries. The first of these facts to attract public attention was the serious hindrance to great industrial undertakings in all civilised countries of the world by the stoppage of German dyes. The second fact which became potent, as the military exigencies involved an increasingly lavish use of artillery of all calibres, was the intimate connection between the production of dyes and the manufacture of high explosives. In Germany the huge plants of the colour factories were easily and swiftly diverted to the making of these essentials. The absence of such establishments in the allied countries was at first a serious drawback to any increased output of the required munitions of war. Then arose the public outcry for the development and protection of "key industries." Outside the German alliance each civilised nation, whether belligerent or neutral, strove to set its house in order as regards the production of synthetic dyes, this branch of manufacture being, as we have seen, a key industry of fundamental importance.

As all civilised countries are coal consumers, and some are also coal producers, it is evident that a determined bid will be made by each industrialised nation for the supply

of its own synthetic dyes and other coal-tar derivatives. If other nations persist in their determination to develop their colour industries it may be predicted with considerable certainty that the new epoch in the history of coal-tar dyes will find nations supplying their own wants and exporting some of their specially good products. The local demand will be satisfied mainly by local producers, but certain very profitable specialties will command a world sale. In the competition for this foreign trade Germany will have a tremendous advantage, because it possesses well-organised colour factories, generously equipped research laboratories, comprehensive libraries, carefully compiled records, and an amenable personnel of thoroughly trained research chemists working under highly qualified direction in a scientific atmosphere. Added to these are the valuable material assets of cheap bromine, potash, and other essentials.

It cannot in fairness be expected that other countries, which have hitherto neglected the factors which make for success in these highly technical industries, can hope immediately to divide the chief prizes with that nation which has assiduously developed each asset, whether material or personal, for more than forty years. Although considerable determination is being manifested on all sides, there is much leeway to make up.

Another point made by Professor Morgan is that the synthetic dye question is in reality part of a much larger problem, the conservation of our resources in fuel. Coal and other combustibles are frequently burnt in a shamefully wasteful manner, no attempt being made to collect and utilise the escaping by-products. The economical combustion of our carbonaceous fuels, such as coal, lignite, peat, wood, etc., and the systematic recovery of the by-products, ammonia and tar, is the first essential step towards the establishment of a flourishing industry of synthetic dyes, drugs, and other pure chemicals. Where fuel is wasted, tar products and their derivatives can never be manufactured cheaply and efficiently.

The immediate products of coal-tar distillation, forming the basis of the synthetic colour industry, constitute a small group of substances, of which the following

furnish the great majority of the so-called coal-tar dyes. These direct coal-tar products—benzene, toluene, xylene, naphthalene, anthracene, phenol, creosol, carbazole, and a few others of minor importance—must usually be converted into more complex derivatives, from which the colours are ultimately produced. These intervening materials are conveniently termed "intermediate products," or, more shortly, "intermediates."

Before the war it was in the production of these essential intermediates that German chemical technologists excelled to the extent of creating a monopoly in this branch of chemical manufacture. The dye-makers of other nations then depended almost entirely on the German supply of these products, and non-German dye-making consisted largely in the assembling of intermediates and the conversion of these substances into finished dyes. Accordingly, it is to the manufacture of intermediates that attention is being chiefly directed by would-be founders of dye factories. If only the difficulties attending the commercial production of intermediates are mastered, a supply of derived dyes will in most cases be assured. Increasing numbers of intermediates are being manufactured in America, including aniline and benzidine and their homologues, *p*-nitroaniline, the naphthols and naphthylamines and an increasing export trade with the United Kingdom is in progress. The strenuous labours of the last four years have shown that methods for producing colour intermediates can be rapidly improvised when cost is not the primary consideration. Workable processes for manufacturing the most needful intermediates have been evolved, and certain members of this important group of synthetic products are now being turned out on a very large scale, although at prices which, generally, are very much higher than those which prevailed before the war. A resolute effort at cheaper production, says Professor Morgan, is a vital necessity, for without it no feasible mode of protection, whether by tariff or by boycott of foreign goods, will be of any avail. If only this effort is forthcoming it is highly probable that the dye industries of the allied countries will be assisted by the altered social and economic conditions of Germany,

arising from the military defeat of this highly organised and cleverly camouflaged slave state. These changes may render it less possible for German industrialists to manufacture at very low rates or to "dump" their finished chemical products, and especially dyes, into allied or neutral countries at prices lower than the cost of production. This levelling up of prices by the foreign competitor should meet half-way the processes of cheapening which need to be practised by our manufacturers of fine chemicals.

At the annual meeting (Sept. 18, 1918) of the Calico Printers' Association, Ltd., the chairman, Mr. Lennox B. Lee, said the Association was the largest consumer of dyes in the country. Before the war over 70 per cent of the 2000 dyes they then used were made in Germany and less than 7 per cent were British. Of about 230 essential base colours only 25 per cent were now being produced by British makers, and about one-third of these were used because no better could be obtained while the cost was 200-1000 per cent above pre-war figures. Of the 230 colours the commoner sorts were obtained from British makers, the finer kinds have still to be brought from Switzerland, and fully half of the number are unprocurable. Restriction on colour imports, which was a natural corollary to the scheme of Government control for the dye-stuff industry, involved a principle which would affect prejudicially the textile trade of the country. Cotton exports in 1913 were valued at over £127,000,000, of which £56,000,000 worth was exported in the coloured state. If the industries which produced this sum were in the future unable to get their colouring matters under equally favourable conditions compared with other countries, they would quickly lose their reputation and trade, and the uncoloured trade would probably follow. New business depended largely on the production of novelties, and foreign dye-makers would not send their new colours to this country if importation of the bulk of their production was prohibited. On the other hand, it has been pointed out that State aid is necessary for the industry because a large amount of plant has to be erected at a high cost, whereas the Germans have still their pre-war plant intact. Professor Morgan states it is

becoming recognised more generally that the establishment under peace conditions of a self-contained British dye industry is an arduous task, requiring continuous service during many years of united efforts in labour, capital, inventive skill, and business organisation of the highest order. To this end there is no road or short cut such as was suggested by the alleged "capture" of 257 German dye recipes, an absurd *canard* to which regrettable prominence was given by the popular press in January 1918.

That Americans are very much alive to the corresponding facts in their own country is shown by their Dye-stuff Tariff Act of September 8, 1916, and the proposed Bill to amend it. This Act, which protected the dye industry in the United States at the time and made home manufacture the criterion of future tariffs, has apparently accomplished its object in encouraging the investment of capital in the United States dye industry, but it now appears that there are several loopholes in the wording of the Act, through which foreign competitors might succeed in evading the import taxes and might thus capture the trade. A draft Bill to remedy these defects in the Act has been issued by the United States Tariff Commission.

One possibility of evasion resides in the fact that many dyes could be imported as leuco bases under the title of intermediates, and could then be converted easily and cheaply into finished dyes by simple oxidation in one process. The Act could also to some extent be evaded by importing highly concentrated dyes instead of the usual commercial brands produced by diluting with salt, dextrine, etc., or a paste of the dye could be diluted further after importation. In the Act of 1916 certain dyes (anthracene and carbazole) were exempted from the specific 5 per cent import duty. In the new Bill it is proposed to include these important vat dyes, as it is just in the manufacture of such colours that the United States is backward. The object of the American census of dyes is to determine the relation between the home production of dyes and the domestic consumption of these substances. If after five years this production is

less than 60 per cent of the consumption of dyes then the special duties levied under the Act of 1916 will no longer be collected. The future protection of the trade in dye and synthetic products is dependent on the growth of the industry within the United States.

The present position of the dye-stuffs industry in this country has recently been discussed by H. Dean of British Dyes, Ltd. (*Journ. Soc. Dyers and Col.*, 1919, 35, 91). During the war the first problem with which dye manufacturers were faced, and one which was solved satisfactorily from the beginning, was the production of sufficient khaki and blue dye-stuff for military and naval purposes. Fortunately, the intermediate products were available, and although the demand was very heavy the supply throughout the war was satisfactory. With other dyes, however, the case was very different, because the German aggressive policy had crushed out British-made intermediate products and had thus crippled the possibilities of the development of the industry in this country. "The next question, therefore, which arose was the erection of a large number of manufacturing plants, which called for considerable chemical and mechanical skill and the expenditure of large sums of money. It was quickly recognised that we were faced with two alternative problems, namely, the production of the maximum number and quantity of colouring matters for consumption during the period of the war and the erection of a large new works and plant for the object of meeting the German competition after the war, or at least of being in a self-contained position in the matter of dye-stuff production, upon which the great textile industry of this country depends. After much careful consideration it was decided that the only rational course to pursue was to work at both problems concurrently, which course was adopted, and has been pursued from that time forward."

Many difficulties in development were experienced during the war, owing to the scarcity of labour and of steel and building materials. Plant erection, therefore, did not keep pace with technical research but progress was made with the erection of the Dalton works at Huddersfield, a works on a scale hitherto unapproached

in this country and in many respects equal to the best of the great German works.

Messrs. Levinstein and Messrs. Claus have also developed along lines of research, and it is most pleasing to read how the former firm, at the outset of the war, grappled with the situation. Indeed, the development of Levinstein's during the last few years shows that initiative and enterprise were not lacking; their chance only came when the tremendous and over-bearing competition of the Germans was removed. At their Ellesmere Port factory they are now producing large quantities of synthetic indigo and some vat dye-stuffs. Then the British Alizarin Company have supplied alizarin and some other alizarin colours during the war, besides catering for the export trade.

Messrs. L. B. Holliday & Co., after beginning with the manufacture of picric acid in 1915, have since produced quantities of intermediates and dye-stuffs. Synthetic drugs have also been produced. Solway Dyes Co. (Morton, Sundour Fabrics, Ltd.) produced indanthrene yellow in small quantities soon after the outbreak of war, and early in 1915 they were making this dye-stuff in quantity. Later they produced alizarin sapphirole, indanthrene blue, and other vat dye-stuffs. They have concentrated on the production of fast dyes.

Messrs. Brotherton & Co. have specialised in metachrome colours, single bath wool dyes, and have acquired the Mersey Chemical Works which was formerly under German ownership. The Clayton Aniline Company, after being engaged largely in explosive manufacture, have now resumed the manufacture of intermediates, and dyes of the azo, sulphur, and basic series. The large gas companies have also added largely to the supply of intermediates.

"After many abortive attempts to establish a community of interests between the principal dye manufacturers in this country, a satisfactory scheme has at last been evolved whereby British Dyes, Ltd., and Levinstein Ltd. have pooled all their resources. The fusion of these two great dye manufacturing firms will result in unity of control, elimination of unnecessary competition and over-

lapping, exchange of ideas, processes, etc. The new company, British Dye-stuffs Corporation, Ltd., will include the works at Turnbridge and Dalton, Huddersfield, the works of Messrs. Levinstein, Ltd., at Blackley and Clayton, Manchester, and the Synthetic Indigo works acquired by Messrs. Levinstein at Ellesmere Port. A splendid site has been acquired in close proximity to the existing works at Ellesmere Port, a site possessing a two-mile frontage to the Manchester Ship Canal, an unlimited supply of water is available, and the effluent can be disposed of into the Mersey with comparative ease. The land is level and is in close proximity to the North Wales coal-fields."

Professor Morgan, discussing the amalgamation of British Dyes, Ltd., and Messrs. Levinstein, Ltd., says: "The new merger has obviously the potentiality of further growth, so that in the future it may embrace other dye-producing enterprises. The fears of those who on principle distrust trade monopolies on account of their repressive and stagnating tendencies should, however, be allayed by a consideration of the very meritorious and successful efforts in dye production made during the last four years, by the amalgamating firms and also by other works at present outside the above-mentioned corporation. Moreover, a further impetus to progress arises from the circumstance that the two branches of the new corporation will remain as separate business entities, although working together under the same directorate. The Board of Trade scheme of assistance to the dye industry is intended to help all British firms engaged in dye production. This financial assistance afforded by the Government will take the form of loans and grants-in-aid for buildings, plant, and research. In return for these privileges the companies thus assisted will be subject to inspection and to a certain degree of Government control.

The primary and essential object of this state aid is the firm and permanent establishment of a British industry in dye production, yielding a supply of dyes more than sufficient for British requirements, thus leading to a substantial export trade with cost of production brought down to a point which will make competition with the very large scale industry of Germany com-

mercially possible. If, as the result of this policy, the dye industry is established sufficiently to meet British demands at reasonable prices the object of the Government will be attained. The economic side of the dye question will be the crucial test in the forthcoming years of reconstruction, and on a satisfactory solution of this part of the problem will depend the future of the British industry in fine chemicals in general and of dyes in particular."

Dean gives figures to show how the British dye-stuff industry was completely dominated by the Germans before the war. Thus Germany produced 74 per cent of the total consumption of £18,000,000 worth of dye-stuffs by the world in 1913, besides providing over one-half of the materials needed to produce the remainder. He mentions prices conventions, such as have been previously referred to, and states that these associations always resulted from a period of destructive competition and excessive fall in prices. Thus the price of synthetic indigo showed the following fluctuations:

			Marks per kilo.
1897–8 . . .	Badische	100% indigo	15·16
1898–9 . . .	Hoechst	,,	12·12·5
1901 . . .	Hoechst	20% paste	2·4
1901 . . .	Badische	,,	2·3
1901 . . .	Hoechst	,,	2·1·2·3
1901 . . .	Badische	,,	2·0
1902 . . .	Badische	,,	1·9
1902 . . .	Hoechst	,,	1·75·1·8
1902 . . .	Badische	,,	1·70·1·75
1902 . . .	Hoechst	,,	1·60·1·65
1904 . . .	Badische	,,	1·50

The fall further continued down to 1·25 marks, until the Indigo Convention was formed and the price maintained at 1·75 marks per kilo.

In the German colour industry price associations were arranged regarding alizarin, Congo dyes, paranitraniline, auramines, and rhodamines, Victoria blue, magenta, methylene blue, resorcinol, beta-naphthol, hydrosulphite, indigo, and aniline. The majority of these associations were ordinary price conventions, but the Aniline Convention and the Alizarin Convention were important international cartels. The terms of these arrangements were,

on the whole, kept very secret, but the policy and details seem to have been settled by committees composed of directors of the participating firms.

None of these arrangements, however, succeeded in eliminating the keen competition between the firms and even the joint working, referred to in a previous chapter, did not attain the desired end. Dean gives a full account of the Berlin-Badische-Bayer and other combinations and states that in about five years after the formation the old condition of acute competition reasserted itself, and even the interchange of contract notes was discontinued. Joint offices opened by Berlin, Badische & Bayer in New York and by Bayer-Berlin in Brussels after the conclusion of the agreement were failures. "These arrangements were continued until 1916, when, in order to prepare to meet past war problems, a much larger community of interests was formed, embracing all the companies already mentioned, viz. Badische Anilin und Soda Fabrik, the Berlin Aniline Co., F. Bayer & Co., Cassella & Co., Meister, Lucius & Brüning, and Kalle & Co., and also Weiler-ter-Meer and P. Leonhardt & Co. (owned by Meister, Lucius & Brüning). The reasons given for the new combination may be summarised as follows: (*a*) The breaking of far-reaching international arrangements by the state of war; (*b*) the desire of the German Government to treat with one body for export purposes; (*c*) the realisation that combination was necessary to maintain, after the war, the position of the German chemical trade; (*d*) the establishment of new factories in England and in the United States; (*e*) the passing of the anti-dumping laws and the threatened revision of the tariff in the United States (now actually effected). The arrangements are for a period of fifty years and profits will be pooled and divided on the basis of the capital of each concern."

Griesheim-Elektron joined the combination in 1917, and all the firms largely increased their capital, making a total of 293 million marks, the capital increase being wholly used for the Badische nitrate business. "In spite of these arrangements," Dean states, "the various manufacturers still keenly competed with one another, and each one having for sale non-syndicated products, they

were able, when occasion demanded, to defeat the objects of the associations of which they were members.

The three Swiss colour-making firms—the Society for Chemical Industry, the Geigy Company and the Sandoz Chemical Works—have called meetings of their shareholders to consider proposals for a close working agreement among the three concerns. It is understood that the arrangement will follow closely that of the German colour-makers, this is to say, there will be a long term agreement, under which profits, processes, and patents will be pooled, but each firm will retain its individuality as far as management is concerned.

As regards the development of the British industry, Dean expressed the opinion that this will depend chiefly on the dogged determination and pertinacity of the British chemist in conjunction with the British manufacturer. The British textile industries must never again be jeopardised by the possibility of the supply of dye-stuffs being cut off. To meet the German competition (1) a large capital expenditure is absolutely necessary. (2) Raw materials, heavy chemicals, acids, alkalis, chrome compounds, etc., must be available at prices not greater than those obtaining in competitive countries. (3) There must be complete recovery and utilisation of by-products, thus ensuring a minimum of waste. (4) The closest bond of unity must be established between science and industry. (5) Complete development of the photographic, drug, and fine chemical products with which the dye-stuffs industry is inseparably bound.

The German capital invested in the production of dye-stuffs is £50,000,000, whereas the corresponding British capital is only £5,000,000. Our rejuvenated dye industry will therefore need careful nursing.

As regards the progress of the dye industry in other countries, it is evident from the patent literature that much research is being done on dye-stuff production in the United States. Owing to the fact that they came into the war at a late period they had advantages over those countries which were engaged in the conflict from 1914, and they had no distractions arising from the mobilisation of their man-power and the diversion of

their manufacturing activities into war industries. Before the war seven American companies assembled German intermediates and converted them into dyes. They used per annum approximately £3,000,000 worth of dyes, of which an amount costing only about £600,000 was made in the United States. At the present time 190 firms are making dyes, drugs, and intermediate products from coal-tar. Of these concerns 81 manufacture coal-tar dyes from American materials, equivalent in total weight to the annual imports before the war, and the total output of the 190 firms is 54,000,000 lbs., of a value of about 69 million dollars. More than 1700 chemists and engineers are employed in research and chemical control of this rapidly developing industry, being about 8·8% of the total personnel of 19,650. The capital of the concerns exceeded £40,000,000 in 1917. The products now manufactured in the United States include numerous colour intermediates from benzol, toluene, and naphthalene. There still remain to be tackled certain finer dyes derived from anthracene and carbazole. Anthracene was not available in America until the summer of 1917. The production of carbazole was expected in 1918. It is significant of the value attached by Germany to the retention of its monopoly in vat dyes derived from anthracene and carbazole that the cargo carried to America by the submarine *Deutschland* in July 1916 contained 400 tons of dyes, chiefly of this class, and in October of the same year another cargo of these dye wares was transmitted by the same means.

For reasons stated above, France and Italy have had little leisure to devote to the production of dye-stuffs, but important work has been done by the Compagnée Nationale des Matières Colorantes et Products Chimiques in the manufacture of synthetic indigo and alizarin and its derivatives, and by the Société des Products Chimiques et Colorantes Français in synthetic dyes, including indulines, nigrosines, and azo-colours for wool and cotton. The two firms have a joint committee intended to avoid overlapping in research and processes.

In Japan the dye-producing factories are under Government surveillance and it is expected that all home requirements will be met.

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